OSCILLOSCOPE

TYPE ST-2B

MODELS
4ST2B1
4ST2B2
4ST2B3

INSTRUCTIONS

OSCILLOSCOPE

TYPE ST-2B

MODELS
4ST2B1
4ST2B2
4ST2B3

Revision A, B

EBI-7020A

ELECTRONICS DEPARTMENT
GENERAL ELECTRIC COMPANY
ELECTRONICS PARK, SYRACUSE, N. Y.

1/53 (600)

Printed in U.S.A.

WARNING

The cathode-ray tube of this instrument is highly evacuated. If it is necessary to remove the tube, the operator should wear protective gloves and safety goggles to protect hands and eyes from flying glass in event of implosion of the tube.

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

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CAUTION

Before attempting to put the oscilloscope into use, the instruction book should be carefully read. Above all, these two operating precautions must be observed:

1. Never allow the beam, when focussed to a fine spot at high intensity, to remain on the face of the cathode-ray tube. A severe burn in the screen material may result. This is particularly true when using long persistance 5UP7 tubes (on the Model 4ST2B2).

2. Use extreme care not to overload the amplifier with d-c when the selector switch is in the DC position. If accidental overload does occur and the Oscilloscope does not function properly, the damage will probably be in the first stage of the amplifier, specifically, the 5879 tubes and/or the cathode resistor R8 or R42. All of these may need replacing.

USER WARRANTY

The General Electric Company warrants to the purchaser of the new General Electric Oscilloscope, Type ST-2B, that any part thereof (except electronic tubes incorporated therein which are covered by the company's standard tube warranties) which proves to be defective in material or workmanship within ninety (90) days from the date of original purchase for use, will be repaired or replaced. Any defect of said Oscilloscope, Type ST-2B, should be brought to the attention of the General Electric dealer from whom it was purchased, who shall be authorized to furnish or arrange for repairs or replacements within the terms of this warranty.

The foregoing is in lieu of other warranties, express or implied, and the General Electric Company neither assumes, nor authorizes any person to assume for it, any other obligation or liability in connection with said Oscilloscope, Type ST-2B.

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OSCILLOSCOPE

TYPE ST-2B

DESCRIPTION

The General Electric Oscilloscope, Type ST-2B, is a high quality instrument designed for general use in laboratories. It features identical vertical and horizontal amplifiers, driven sweep, choice of cathode-ray tube screens, Z axis input, internal voltage calibrator, and portability combined with quality construction. A low capacity input probe, Catalog No. 101J229G1, is an accessory available at extra cost.

The Model Number designates the type of cathode-ray tube used. The Model 4ST2B1 Oscilloscope is a Type ST-2B design unit with a 5UP1 (medium persistance) cathode-ray tube. The Model 4ST2B2 Oscilloscope is a similar unit with a 5UP7 (long persistance) cathode-ray tube. The Model 4ST2B3 Oscilloscope is another similar unit with a 5UP11 (short persistance blue fluorescence cathode-ray tube.)

Both amplifiers are direct-coupled and have sufficient bandpass with slow roll-off to insure faithful reproduction of square waves from 0 to 30 kc. To provide good stability, both the screens and the filaments of the first stages are regulated. The remainder of the amplifiers are of a balanced type which are relatively free from disturbances caused by unstable power line conditions.

The amplifiers are adjusted in the factory for zero phase shift between amplifiers from 0 to 300 kc. (See MAINTENANCE section on phase shift measurements.)

The vertical selector switch is designed to allow the selection of probe, a-c, d-c, or calibration voltages, without moving any connecting leads.

The horizontal selector switch permits choice of a-c, d-c, calibration, ± internal sync, ± line sync, and - external sync.

A four-position attenuator switch on either vertical or horizontal input provides attenuation sufficient to study voltages from 5 millivolts to 500 volts rms. The 10 to 1 vernier gain controls are conveniently arranged concentrically with the attenuator switches.

A gas tube type sweep provides a coverage of frequencies from 2 cycles to 30 kc, either recurrent or triggered. Again, concentric controls are used for coarse and fine frequency adjustments. Should lower sweep frequencies be desired, external capacity may be added at the jacks provided on the panel. Retrace blanking is provided as well as a blank input on the front panel for external blanking or Z-axis modulation.

To improve the usefulness of the Oscilloscope for pulse observation, adequate sweep voltage and horizontal gain is provided to expand the sweep at least 16 inches beyond the edge of the tube. Considerable expansion beyond this is possible; however, due to overload in the first stage causing a shift in B+, a small shift vertically will result. The amplifiers exhibit negligible nonlinearities in the on-screen portion of the trace.

A calibrate switch is provided on the front panel to aid in the amplitude measurement of the voltage under test. An output jack is also provided to permit the use of this voltage for calibration of other devices (with a one-megohm input). A sample of the sawtooth sweep is also available at this jack.

Since all amplifier stages are direct coupled, the positioning controls are positive in action, i.e., the trace responds immediately to a change in the positioning control settings.

All operating controls are located on the front panel and access to the deflection plates for direct connection is made by simply turning a switch and connecting to the binding posts on the rear of the case.

The Oscilloscope is housed in a grey wrinkle cabinet and the panel has etched lettering and an attractive brushed aluminum background. Only two screws need be removed to slide the chassis out of the case for service adjustments.

A removable light shield for the cathode-ray tube is provided, as well as a 1/4-inch thick safety glass. The latter may be removed by simply removing three mounting nuts from the external housing ring.

The Oscilloscope is completely self contained and is wired to operate from a 50/60 cycle 115-volt power line. By a simple wiring change, it may be operated from a 230-volt source.

SPECIFICATIONS
(Based on a nominal 117-volt line)

1. FREQUENCY RESPONSE

A. Vertical Amplifier

1) DC - 0 to 400 kc, +0, -20%, not more than 50% down at 700 kc. Good square wave response 0 to 30 kc at any gain or attenuator setting.

2) AC - 10 cycles to 400 kc, +0, -20%, not more than 50% down at 700 kc. Good square wave response 100 cycles to 30 kc at any gain or attenuator setting.

3) Probe - 2 cycles to 400 kc, +0, -20%, not more than 50% down at 700 kc. Good square wave response 30 cycles to 30 kc at any gain or attenuator setting.

B. Horizontal Amplifier

1) DC - 0 to 400 kc, +0, -20%, not more than 50% at 700 kc. Square wave response 0 to 30 kc at any gain or attenuator setting.

2) AC - 10 cycles to 400 kc, +0, -20%, not more than 50% down at 700 kc. Square wave response 100 cycles to 30 kc at any gain or attenuator setting.

2. SENSITIVITY

A. Vertical

1) AC - 10 mv rms/inch.

2) DC - 28 mv d-c/inch.

B. Horizontal

1) AC - 15 mv rms/inch.

2) DC - 42 mv d-c/inch.

C. Probe

130 mv rms/inch.

D. Deflection Plates Direct

1) Vertical - 22 volts rms/inch.

2) Horizontal - 25 volts rms/inch.

3. INPUT IMPEDANCE

Vertical (AC or DC)	1 megohm shunted by 35 mmfd.
Horizontal (AC or DC)	1 megohm shunted by 45 mmfd.
Probe	1 megohm shunted by 10 mmfd.
Deflection Plates	470,000 ohms, 18 mmfd.
Z-Axis	150,000 ohms, 50 mmfd.
External Sync	50,000 ohms, 115 mmfd.

4. SWEEP

A. Range

Triggered or recurrent - 2 cycles to 30 kc (may be extended downwards by adding external capacity across panel jacks).

B. Sync

±Internal, ±Line and -External (requires -0.3 volt peak-to-peak for external sync).

C. Sweep Expansion

At least 4 times tube diameter.

5. LINEARITY

A. Vertical

Less than 10% nonlinearity at 4 inches.

B. Horizontal

Less than 10% nonlinearity at 4 inches.

6. PHASE SHIFT

Negligible phase shift between amplifiers from 0 to 300 kc.

7. BLANKING

Z-Axis blanking requires 20 volts peak to blank.

8. CALIBRATION

Eight voltages available by selector switch: 0.1, 0.3, 1, 3, 10, 30, 100, and 300 volts peak-to-peak, ± 15%.

9. DIRECT CONNECTION TO DEFLECTION PLATES

Available through capacitors, internal positioning circuits still function.

10. AMBIENT TEMPERATURE RANGE

0 to 40° C.

11. POWER REQUIREMENTS

105-125 volts, 50/60 cycles power consumption approximately 120 watts. (By a simple wiring change, may be operated from 210-250 volt line.)

12. TUBE COMPLEMENT

4 - 6BK7	1 - 0A2
4 - 5879	1 - 884
2 - 12AU7	1 - 5UP1 (Model 4ST2B1)
1 - 1B3GT	1 - 5UP7 (Model 4ST2B2)
1 - 5Y3GT	1 - 5UP11 (Model 4ST2B3)

13. MECHANICAL

Height	-	15-1/2 inches
Depth	-	17 inches
Width	-	10 inches
Weight	-	45 pounds

FUNCTION OF CONTROLS

The controls of the ST-2B Oscilloscope are divided into four major groups, which are explained in the following paragraphs. The fifth section explains the binding posts and jacks. An occasional glance at Fig. 1, Operating Controls, will aid the reader to visualize the operation of the control referred to.

1. CATHODE-RAY TUBE CONTROLS

A. INTENSITY (R89)

The INTENSITY control is located in the negative end of the voltage divider across the high-voltage power supply. It controls the bias voltage applied to the control grid of the cathode-ray tube, and consequently the rate of flow of electrons in the beam.

B. FOCUS (R87)

The FOCUS control is also located in the voltage divider, but at a less negative point. Its variable voltage is applied to the first anode of the cathode-ray tube, and controls the electrical focal length of the electron gun. In this manner, correct focussing is achieved for the brilliance level selected by the setting of the intensity control.

C. ASTIGMATISM (R82)

The ASTIGMATISM control is connected between the B+ and the negative bus. It supplies an adjustable voltage to the second anode of the cathode-ray tube. This control should be adjusted until a sharp, clear trace is obtained. It should be borne in mind that this adjustment is interacting with the FOCUS control.

D. VERT POSITION (R23)

The vertical positioning control is located between the two cathodes of V3. Changing its setting shifts the bias of both sections of V3 in opposite polarity, thus changing the current through the tubes and the voltage level at the plates. This shift is further amplified by V4 and thus results in a shift in the position of the trace.

E. HORIZ POSITION (R57)

The horizontal positioning control is located between the two cathodes of V7 and works in the same manner as the vertical positioning control.

2. SWEEP CIRCUIT CONTROLS

A. FREQ-CPS (S6)

The sweep frequency range switch controls the coarse range selection of sweep frequency by selecting one of the sweep capacitors C32-C39.

The vernier control (R66) provides for exact adjustment of the sweep frequency between the steps selected by the range switch. By varying the value of R66, the time constant of the RC network (R66 and C32 - C39) varies, and hence the frequency.

B. SWEEP TRIG-RECUR (S5)

The sweep switch determines the amount of bias on the 884 tube (V9), and thus dictates whether the sweep free-runs or must be triggered. The SWEEP HOLD control (R71, located on the chassis), sets the bias to the proper value for the particular 884 in the circuit. The SWEEP LEVEL control (R74, located on the chassis), is used to set the output of the sweep to an average value of zero volts d-c before the sweep is fed into the horizontal amplifiers.

C. HORIZ SELECT (S4)

The horizontal selector switch provides for a choice of ±internal sync, ±line sync, or -external sync. In addition, it also provides for selection of a-c or d-c input to the horizontal amplifier, and turns the sweep generator off at these two latter positions. An eighth position called SET is provided to switch the sweep generator output to the vertical amplifier to aid in alignment of the horizontal amplifier. A calibration position is also available for amplitude measurements of signals applied to the horizontal amplifier.

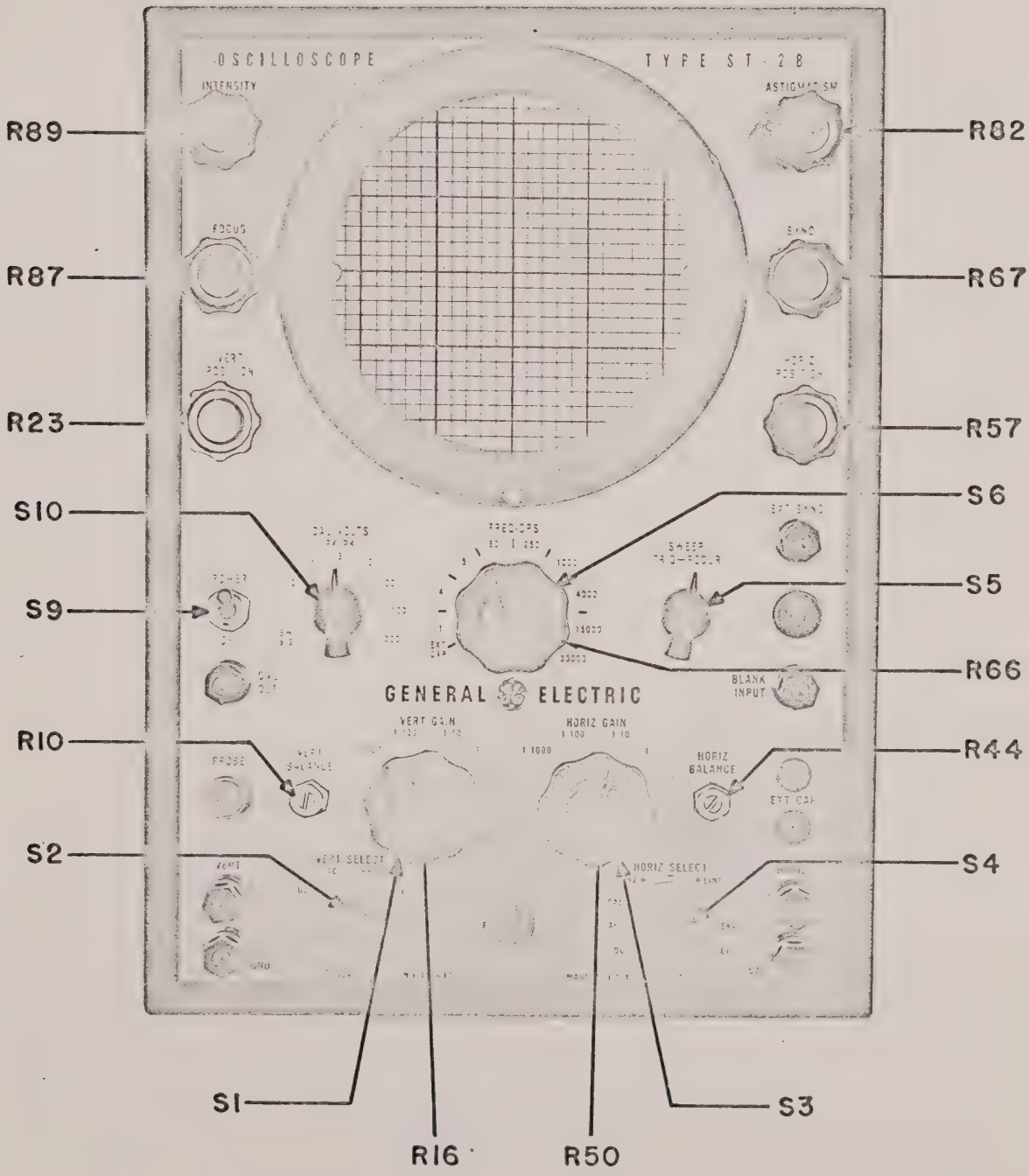


Fig. 1 Operating Controls, Oscilloscope, Type ST-2B

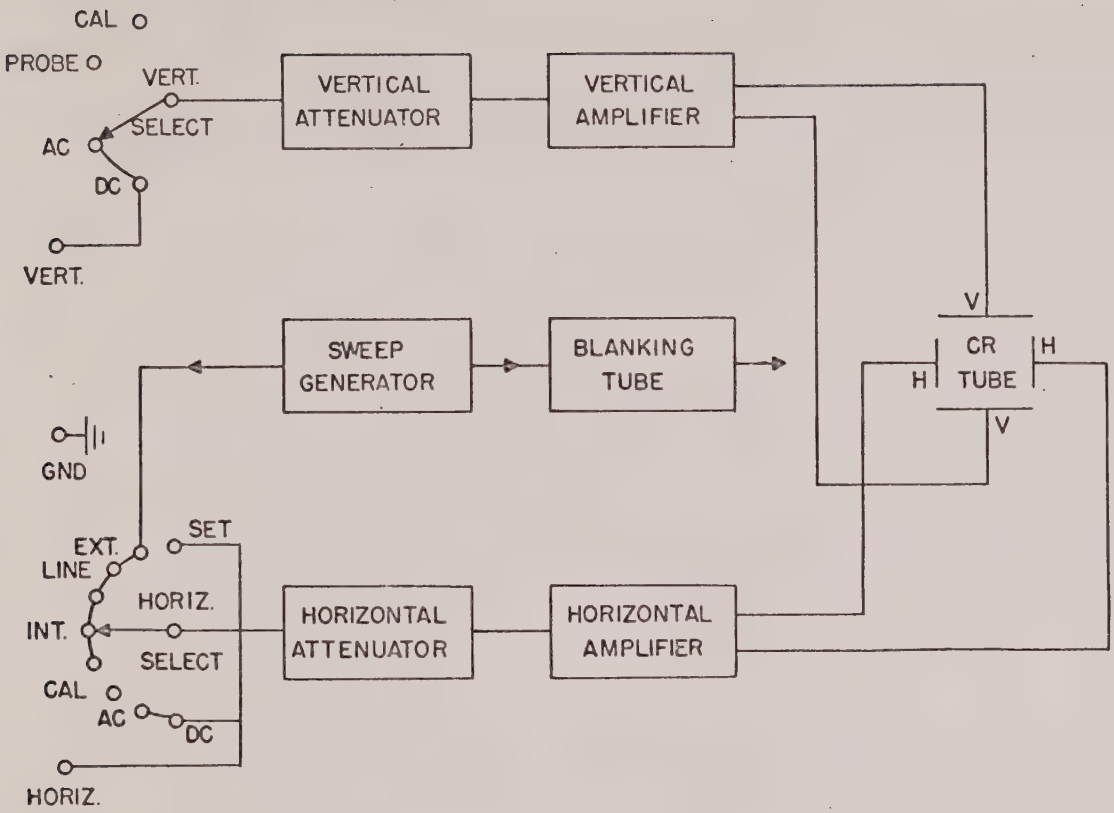


Fig. 2 Block Diagram

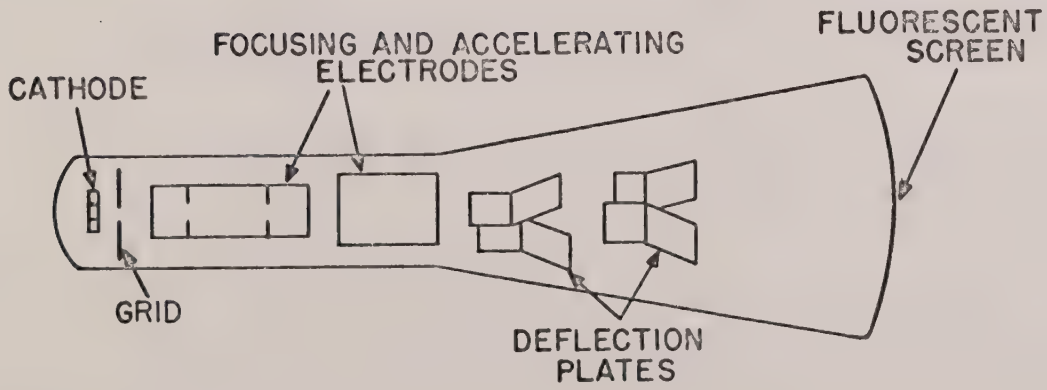


Fig. 3 Cathode-Ray Tube

D. SYNC (R67)

The sync amplitude control adjusts the amount of sync signal fed to the grid of the 884. Only the minimum amount of sync voltage necessary for syncing positively should be used, otherwise severe distortion of the sweep may result.

3. AMPLIFIER CONTROLS

A. VERT GAIN (S1)

The vertical attenuator switch provides four fixed steps of attenuation (1, 1/10, 1/100, and 1/1000) in the input section of the vertical amplifiers. It thereby permits input signals up to 700 volts peak to be observed on the oscilloscope.

The vertical gain vernier control (R16) varies the amount of output from V1 and V2 (and hence controls the gain of the amplifier) by controlling the amount of resistance between the plates of V1 and V2. It provides for more than a 10 to 1 change in gain.

B. VERT BALANCE (R10)

The vertical balance control is used to adjust the screen voltage of V1 and V2 so that the plate voltages are equal. This prevents the beam from moving as the gain control is adjusted. It should be set occasionally as needed as described in the MAINTENANCE section.

C. VERT SELECT (S2)

The vertical selector switch provides for the selection of a-c, d-c, probe, or calibration voltages to the vertical amplifier.

D. HORIZ GAIN (S3)

The horizontal attenuator switch provides four fixed steps of attenuation (1, 1/10, 1/100, and 1/1000) in the input section of the horizontal amplifiers. It permits input signals up to 700 volts peak to be observed on the oscilloscope.

The horizontal gain vernier control (R50) varies the amount of output from V5 to V6 (and hence controls the gain of the amplifier) by controlling the amount of resistance between the plates of V5 and V6.

E. HORIZ BALANCE (R44)

The horizontal balance control is used to adjust the screen voltage of V5 and V6 so that the plate voltages are equal. This prevents the beam from moving as the gain control is adjusted. It should be set occasionally as needed as described in the MAINTENANCE section.

4. MISCELLANEOUS

A. CAL VOLTS PK-PK (S10)

The calibration switch provides a choice of eight calibration voltages or a sample of the sweep voltage for either internal or external use.

B. Deflection Plate Switches (S7 and S8 at Rear of Case)

The deflection plate switches provide for disconnecting the cathode-ray tube deflection plates from the amplifiers and connecting them to binding posts (J8, J9, J10, and J11) for direct external connection.

C. POWER OFF (S9)

The power switch provides an on-off switch in the primary of the power transformer. A pilot light indicates when power is on.

5. BINDING POSTS

A. VERT (J2)

Signals may be fed into the vertical amplifier via the a-c d-c binding post J2.

B. PROBE (J1)

When using the low capacity input probe, available as an accessory, the signal is fed to the vertical amplifier via J1.

C. HORIZ (J4)

When the horizontal amplifier is used for external signals rather than for sweep amplification, the signal is fed to J4.

D. EXT SYNC (J14)

When external synchronization of the sweep is desired, the external sync signal should be connected to J14. Approximately -0.3 volt peak is enough for most applications.

E. BLANK INPUT (J12)

Z-Axis blanking from external signals is possible by feeding the desired blanking signal into J12. Approximately -20 volts peak is required for blanking (or +20 volts for intensifying).

F. CAL OUT (J13)

The calibration output is a convenient source of the internal calibrating voltage and may be used for external calibration, provided the input resistance of the equipment to be calibrated is approximately one megohm. The sweep voltage is also available at this jack at an output impedance of approximately 10,000 ohms.

G. Deflection Plate Binding Posts (J8, J9, J10, J11)

Direct connection to the deflection plates can be made by turning the switches S7 or S8, and connecting to the binding posts J8 and J10 or J9 and J11. (These switches and binding posts are located on the rear of the case). The binding posts are capacitively coupled to the deflection plates, thus permitting the internal positioning circuits to remain functioning. The upper post on both vertical and horizontal plates is positive and will cause deflection from a positive signal to the right or upward respectively.

THEORY OF OPERATION

Refer to the Elementary Diagram Fig. 14.

The cathode-ray Oscilloscope is an instrument designed to show the variations of one voltage in relation to another, or in relation to time. Since in the great majority of cases it is desired to observe the variations of an unknown voltage with respect to time, the Oscilloscope has a voltage generator built in to furnish a sawtooth voltage that moves the spot of illumination across the cathode-ray tube screen at a constant rate. This allows the instrument to electrically plot the graph of the unknown voltage with respect to time. The screen persistence of the cathode-ray tube blends the successive spots of illumination into a complete picture.

The ST-2-B cathode-ray Oscilloscope is shown in block diagram form on Fig. 2. The equipment consists of a cathode-ray tube, two separate amplifier circuits to amplify small voltages for application to the cathode-ray tube deflection plates, a time base or sweep generator circuit, and the necessary electronic power supply.

1. THE CATHODE-RAY TUBE

The cathode-ray tube is a vacuum tube with a construction as shown on Fig. 3. Electrons emitted by the hot cathode are accelerated greatly and are formed into a beam by a series of tube elements that act as an electron lens. This beam is allowed to strike a fluorescent screen which gives off visible light at the point of impact.

As in the case of the ordinary vacuum tube, the control grid controls the amount of electron flow. Since the amount of electron flow directly affects the brightness of the trace, the illumination level is controlled

by varying the amount of grid voltage of the tube. This control is brought out to the front panel and is called the INTENSITY control.

Since the electrons emitted by the cathode fly off in all directions it is necessary to control and focus them into a narrow beam. This is accomplished by the focussing and accelerating electrodes, which act in the same manner as the optical lens system of a camera, except in this case the electron beam is focussed rather than the light beam. By adjusting the voltages applied to the focussing electrodes, the beam diameter is controlled. This control is also mounted on the front panel and is called the FOCUS control.

After passing the focussing and accelerating electrodes, the electron beam passes between two pairs of deflecting plates which are mounted at right angles to each other. If a voltage difference is applied between one set of plates, the electrostatic field will move the beam toward the plate with the more positive potential. A similar action takes place if a potential difference is applied between the other set of plates. Due to the fact that the second pair of plates is physically mounted perpendicular to the first pair of plates, deflection in both the vertical and the horizontal directions may be obtained. Since the face of the cathode-ray tube is covered by a transparent shield marked off as a graph, horizontal deflections of the beam are often referred to as deflections along the X axis, while vertical movements correspond to deflections along the Y axis.

Because electrons have negligible mass, the beam can be deflected rapidly without appreciable time lag, allowing the reproduction of rapid voltage variations.

2. DEVELOPMENT OF SWEEP

Since in many instances we wish to view one unknown voltage with respect to time, the instrument has a built-in sweep generator, whose simplified circuit is shown in Fig. 4.

The sweep generator uses a Type 884 inert-gas-filled thyratron (V9) designed especially for use as a sweep circuit oscillator. When "free-running", the tube functions as a discharge tube connected in parallel with capacitor C32 (to C39), selected by the setting of S6 the sweep frequency range switch. The discharge potential is determined by the cathode bias, which is in turn determined by the setting of the sweep hold control (R71) in the voltage divider R71, R73, and R107. Resistor R70 is shorted out by S5B, and S5A connects the sync limiter (CR1) into the grid circuit. The germanium diode, CR1, limits the sync signal to a low value, thus preventing over-synchronization and possible distortion of the sweep. When B+ is applied to the circuit, the selected capacitor charges until the plate of the tube reaches the ionization potential, at which point the tube starts to conduct. The plate voltage falls rapidly, discharging the capacitor and producing a sawtooth wave. When the capacitor is discharged, the cathode bias cuts off the tube and the cycle is repeated. The frequency of operation of the sweep generator is determined by the time constant of the R-C network which is varied by the setting of both R66, the frequency vernier control, and the capacitor selected by S6, the coarse frequency range switch.

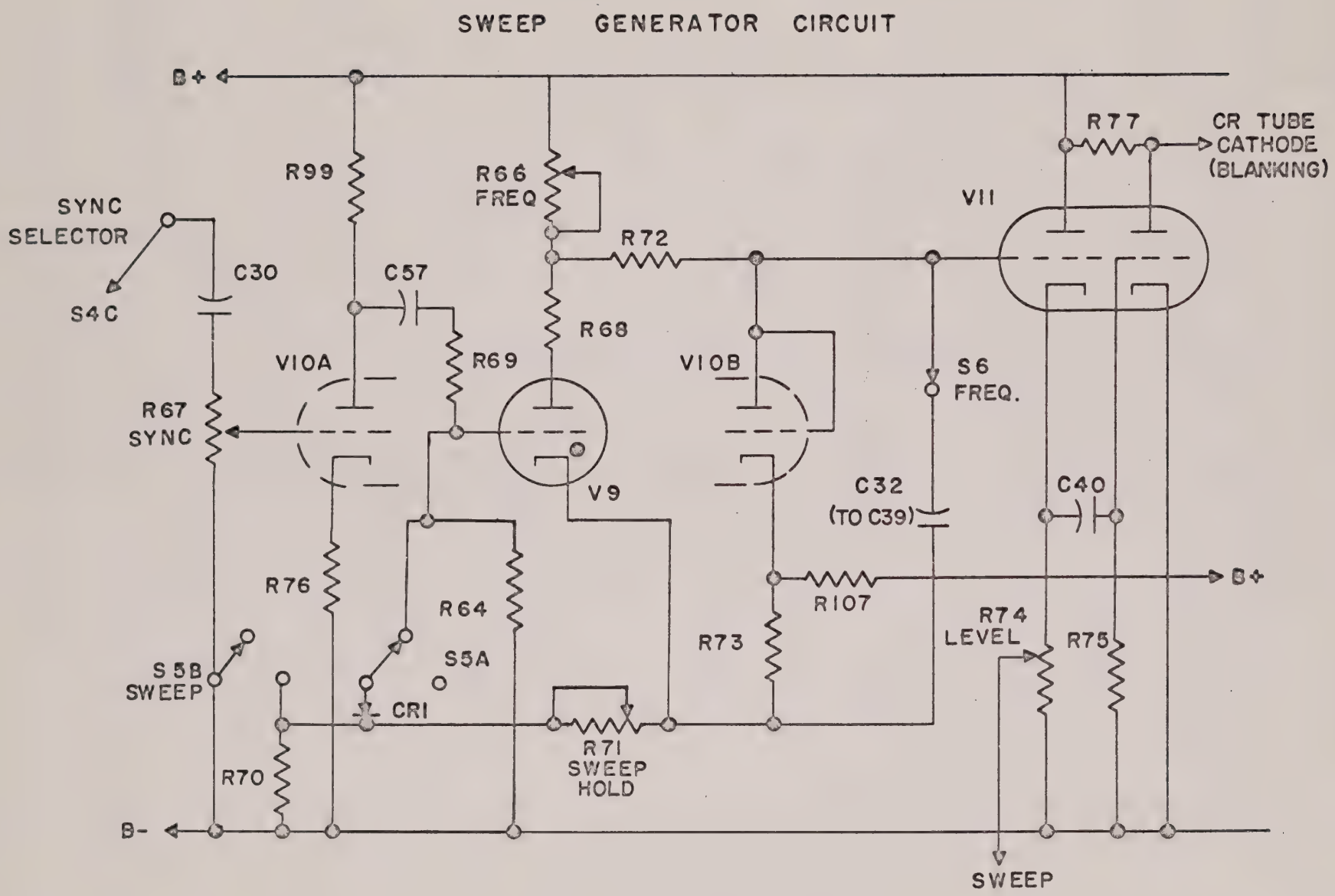


Fig. 4 Sweep Generator Circuit Diagram

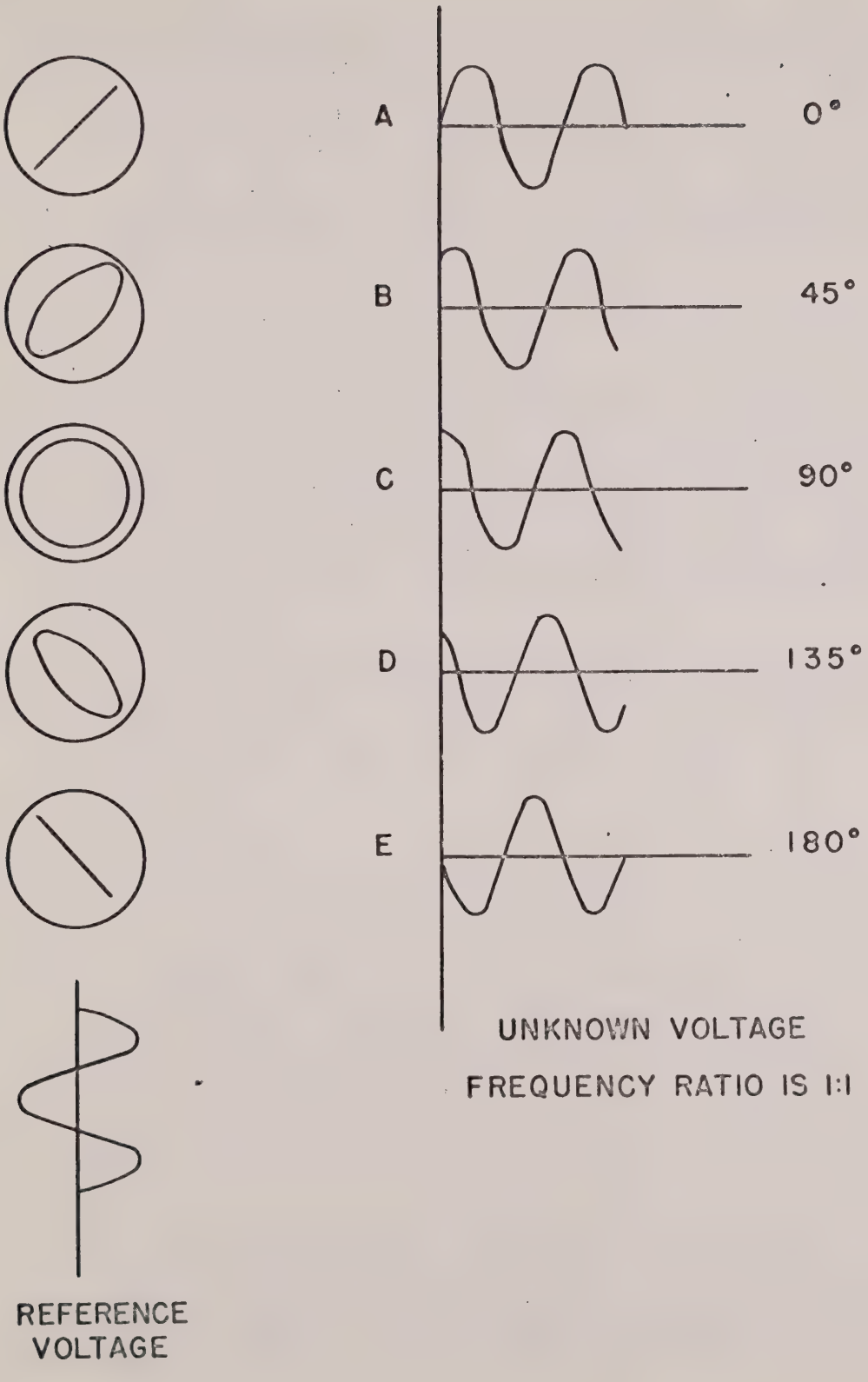


Fig. 5 Lissajous Figures Showing Phase Differences

The sweep output is taken from the cathode follower V11A which provides isolation for the sweep circuit and a low-impedance input for the horizontal amplifiers. The SWEEP LEVEL control (R74), connected to the -33 volt bus, is used to adjust the average level of the sweep to zero volts.

The output is also differentiated by C40 and R75 and applied to the blanking tube, V11B. The blanking tube amplifies the resultant pulse and it is then applied to the cathode of the CR tube, interrupting the flow of electrons during the retrace of the sweep.

For triggered operation, using an external synchronizing signal, the mode of operation is slightly different. The SWEEP TRIG - RECUR switch is put in the TRIG POSITION (as shown on Fig. 4). R70 is added to the cathode biasing network, raising the bias on the thyratron to the point where it will not conduct until a positive trigger is applied to the grid. The external synchronizing signal is connected to the EXT SYNC binding post, and is fed to an amplifier, V10A, through the HORIZ SELECT switch (S4C). R67, the SYNC control, is a gain control in the grid circuit of this tube, and is adjusted to give the minimum amount of signal necessary for proper external synchronization. As before, when V9 conducts, the selected range capacitor is discharged, producing a sawtooth. The cathode follower, V11 functions just as before.

V10B, diode-connected, acts as a clamp on the grid of V11A. It prevents the capacitors from charging up to B+, keeping the sawtooth in the linear range of the charging curve. When external synchronization is used, V10B also holds the plate voltage down, so that the thyratron will not discharge until a trigger is received on its grid.

3. AMPLIFIERS

The horizontal and vertical amplifiers are essentially identical, and the following discussion is applicable to either one.

The first amplifier stage uses two Type 5879 pentodes whose cathodes are coupled directly together. The signal is fed to the grid of V1 (or V5) and appears on the cathodes of both tubes. The grid of the other tube is grounded, producing a push-pull output at the plates. Adjustment of the cathode bias by the BIAS control (R9 or R43) varies the current through the tubes and is adjusted to give the proper d-c level at the plates. The plates are balanced by adjustment of the BALANCE controls (R10 or R44). The gain of this stage is controlled by varying the resistance between the plates by means of the vernier gain control (R16 or R50).

The second and third stages provide additional amplification as well as d-c level adjustments in the second stage. Both these stages employ a type of cross-neutralization which reduces the input capacity of the tubes. This is accomplished by the use of variable ceramic trimmer capacitors connected from plate to opposite grid of each stage, thus providing a small

amount of positive feedback which in turn reduces the amount of input capacity and thus reduces the requirements of the previous stage.

The LINEARITY controls (R22 or R56) adjust the over-all cathode bias to allow for variation in tubes and thus permit the tubes to operate in their most linear portion. The POSITION control (R23 or R57) is used to shift the cathode bias of each section of the second stage, and thus position the trace by adjusting the voltage level on the deflection plates of the cathode-ray tube.

4. VERTICAL AMPLIFIER INPUT CIRCUITS

The vertical selector switch (S2) provides a choice of four inputs to the vertical attenuator switch. The first two positions DC and AC connect to the vertical input binding post (J2) either direct or through a 0.5 microfarad 600-volt capacitor (C60). The third position, PROBE, connects the input to the probe connector (J1) through a 1 microfarad capacitor (C60). A compensated shunt (R34 - C15) results in an additional 10 to 1 attenuation in this position. The CAL position provides an a-c calibrating voltage from the CAL VOLTS switch.

The vertical gain attenuator (S1) is a compensated voltage divider providing four attenuation ratios: 1, 1/10, 1/100, and 1/1000. It may be adjusted as described in the MAINTENANCE section for optimum performance.

5. HORIZONTAL AMPLIFIER INPUT CIRCUITS

The horizontal selector switch (S4) provides a choice of eight inputs to the horizontal attenuator switch. The DC position provides a direct connection input from J4, or through capacitors C29 and C59 when the switch is in the AC position. In the CAL position the input is connected to the calibrating voltages from the CAL VOLTS switch. On the + INT -, + LINE -, and EXT positions, the sweep generator is operating and the signal produced is fed to the horizontal amplifiers, providing a time base. In the SET position, the horizontal amplifier is directly connected to the input binding post J4. At the same time the sweep generator is turned on. The sweep signal is fed to the vertical amplifiers for purpose of frequency alignment by setting the CAL VOLTS switch on the SW SIG position and the VERT SELECT switch on CAL. Sync may be obtained by feeding a sync signal to the top of C30 (located near the sync amplitude control).

The horizontal gain attenuator (S3) is a compensated voltage divider identical to the vertical gain attenuator.

6. DIRECT CONNECTION TO DEFLECTION PLATES

Direct connection to the deflection plates through input capacitors C41 - C44 may be made at J8 - J10 by turning switch S7 to S8 to the other position. The amplifiers are then not used, but the d-c positioning circuits still function through the 4.7 megohm resistors R78 - R81. The

attenuators and vernier gain controls should be set at minimum to prevent any low-frequency signal arriving at the deflection plates via the amplifiers.

7. POWER SUPPLY

The high-voltage supply, the +370, +120, -33, and filament supplies all operate from the same power transformer, T1. The high-voltage supply uses a high-vacuum Type 1B3GT halfwave rectifier with an R-C pi-type filter (R104, R90, C54 and C49) to which the negative voltage divider R85 - R89 is connected from the -33 volt bus. The voltage divider provides the accelerating and control voltages for the cathode-ray tube.

The intermediate supply uses a Type 5Y3GT full-wave rectifier with an L-C pi-type filter to furnish the +B voltage. From this supply, the Type 0A2 glow tube in series with R91 and R93 establishes the regulated screen supply for the first amplifier stages.

The filament supply (W, X, Y, and Z) includes a ballast lamp (RT-1) in series with the heaters of the tubes in the first amplifier stage. This regulates the heater current, minimizing the effect of line variations in this first stage.

8. CALIBRATION VOLTAGES

The calibration voltages are provided to the output jack (J13) and the horizontal and vertical selector switches by a voltage divider across half of the transformer secondary winding. The amplitude is determined by the setting of the CAL VOLTS switch (S10). As this voltage is directly from the transformer, power line variations will affect the output values by the same percentage as the power line change.

APPLICATIONS

The field of application of the cathode-ray Oscilloscope is very broad and is expanding daily. It would be impossible to list and describe all possible uses of the instrument in a book of this sort; however, the following pages illustrate the basic testing procedures and techniques which may be applied in many situations. For advanced material, the reader is referred to standard-practice texts.

1. GENERAL

In the most common use of the cathode-ray Oscilloscope, the voltage wave under study is applied to the vertical deflection plates of the cathode-ray tube while a linear time-base signal of equal or sub-multiple frequency is applied to the horizontal plates. The resulting trace will then show one or more cycles of the voltage being studied.

To diagnose trouble in an equipment, the Oscilloscope user must know what voltages and wave shapes should exist if the circuits are functioning normally. Otherwise the readings and measurements he makes will be of little value. Similarly, if phase relationships are being studied, the patterns obtained will not help correct the difficulties unless a comparison can be made against patterns obtained when the equipment is known to be in good operating order. Fortunately, most instruction books for electronic equipment illustrate the various waveforms which should be obtained at different points in the circuit if the equipment is functioning normally and these illustrations can be used as a standard for comparison.

It should be realized that the field of electronics embraces an almost infinite variety of equipment and it is impossible to illustrate the many applications of the Oscilloscope in each of these equipments. However, by studying the basic circuits and applications described in this portion of the book, the user can quickly familiarize himself with the fundamentals of oscilloscopic service work and then proceed to more specific applications. Such applications are usually covered in detail in the instruction books accompanying the electronic equipment.

2. OBSERVATION OF WAVEFORMS

The cathode-ray Oscilloscope is primarily a voltage indicator, that is, it gives a picture of a voltage waveform. However, current waveforms may be observed by connecting the Oscilloscope across a resistor which has been placed in series with the current load.

In order to obtain an accurate representation of the unknown voltage being tested, some precautions are essential. For the protection of the operator and instrument, the approximate voltage of the operating circuit should be known, as voltages over 700 volts peak may break down the oscilloscope insulation. To insure that the waveform is not distorted by overdriving of the amplifiers, pattern sizes should not exceed 4 inches. If it is desired to observe voltages in excess of 700 volts, an external voltage divider can be used to reduce the voltage to a suitable value for testing. Care should be taken that the new divider does not introduce distortion.

At this point it is worthwhile to note several common causes of unsatisfactory oscilloscope performance that may be eliminated or minimized by careful operating procedure.

The first of these is stray pickup. The cathode-ray tube is protected against stray fields by an aquadag coating on the interior of the tube and a grounded metal shield on the outside of the tube. Connecting all test instruments of a bench to a good earth ground will aid in eliminating stray pickup troubles. Further, the use of long, unshielded test leads should be avoided. Long leads of this type pick up noticeable stray fields and distort wave patterns. The use of the probe input or low capacity coaxial cable is recommended where this is possible.

Another source of avoidable operation distortion is the use of excessive synchronization voltage to lock-in the picture. A good practice is to reduce the SYNC control to zero and almost stop the picture on the screen with the vernier frequency control. Advancing the SYNC control slightly will then lock-in waveform without distortion.

In general, the input impedance of the ST-2B will be much greater than the point under test. The oscilloscope will not, therefore, load down the operating circuit. In a few instances, where the circuit impedance is very high the oscilloscope may change the circuit characteristics, but a satisfactory pattern may usually be obtained by using an isolating resistor between the scope and the circuit under test.

3. THE GENERATION OF LISSAJOUS FIGURES

The difference in frequency and phase of two sinusoidal voltages may be readily studied with a cathode-ray Oscilloscope. By applying one sine wave to the vertical input and the other waveform (or a standard) to the horizontal input, the result is a closed figure known as a Lissajous figure. For correct interpretation of a figure, it is important that the amplitude of both horizontal and vertical deflection be the same.

4. MEASUREMENT OF PHASE

If two cyclic voltages, in phase and of the same fundamental frequency, were impressed on the horizontal and vertical inputs of the Oscilloscope the resulting figure would appear as a straight line 45 degrees off horizontal as on Fig. 5A. In Fig. 5B the two voltages differ in phase by 45 degrees forming an ellipse. When two voltages are 90 degrees out of phase, the figure is a circle (Fig. 5C). Succeeding Figs. 5D and E show other phase relationships to the reference voltage.

Ellipses of different degrees indicate various phase relationships between two input voltages. If equal gain exists on both horizontal and vertical amplifiers the phase angle may be calculated from measurements on the screen (Fig. 6) and substitution in the following equation:

$$\sin \theta = \frac{C}{D}$$

5. MEASUREMENT OF FREQUENCY

Quite often it is necessary to know the frequency of an unknown waveform. The method of obtaining this information is simple by use of Lissajous figures. It is necessary to have a calibrating frequency or a calibrated variable oscillator available. Source of calibration for a variable audio oscillator is the power line frequency, which is most localities is kept very nearly constant.

The unknown signal is fed into the vertical amplifier and the calibrated audio oscillator signal is fed into the HORIZ and GND terminals (HORIZ SELECT switch set to AC). The gain of each amplifier is adjusted to obtain the same amount of deflection in the vertical and horizontal directions. Now the variable oscillator frequency is adjusted until a pattern like that of Fig. 7 appears. The frequency of the calibrated oscillator is then the same as the unknown voltage, indicating a ratio of 1 to 1. Stationary patterns appear whenever a whole number ratio exists between unknown and known frequencies. Thus patterns would be formed at 2 to 1, 3 to 1, 3 to 2, etc. On Fig. 7 are illustrations of several mathematical ratios possible.

From analysis of any stationary picture it is possible to determine the frequency ratio that exists between waveforms. The general equation is as follows:

$$\frac{\text{Horizontal Axis Frequency}}{\text{Vertical Axis Frequency}} = \frac{\text{Number of Loops Touching AB}}{\text{Number of Loops Touching BC}}$$

Referring to Fig. 7, the vertical line AB has two points of tangency to the pattern, the horizontal line BC has three points of tangency to the pattern. Therefore, applying these figures to the formula, keeping in mind that we know the reference horizontal input frequency.

$$\frac{Fh}{Fv} = \frac{2}{3}$$

or

$$Fv = \frac{3}{2} Fh$$

Thus if Fh happens to be 60 cycles, Fv will be $\frac{3}{2}$ x 60 or 90 cycles.

It is imperative to keep in mind that these figures are always closed figures, and that it is possible that traces may fall one over the other. Thus, care must be taken in analyzing the patterns to get the correct ratio.

6. MEASUREMENT OF VOLTAGE

Either a-c or d-c voltages can be measured with good accuracy by comparison of the deflection of the unknown voltage against the deflection caused by a calibrating voltage. It should be remembered that when a-c voltages are compared to d-c voltages, the final figure of a-c corresponds to peak-to-peak voltage reading, because the Oscilloscope reads peak-to-peak.

If a-c voltages only are to be measured in a circuit in which d-c is present, connections should be made to the VERT and GND binding posts, and the VERT SELECT switch should be set to the AC position. The frequency of the a-c voltage should not exceed 400 kc, because the amplifier response drops off above this frequency.

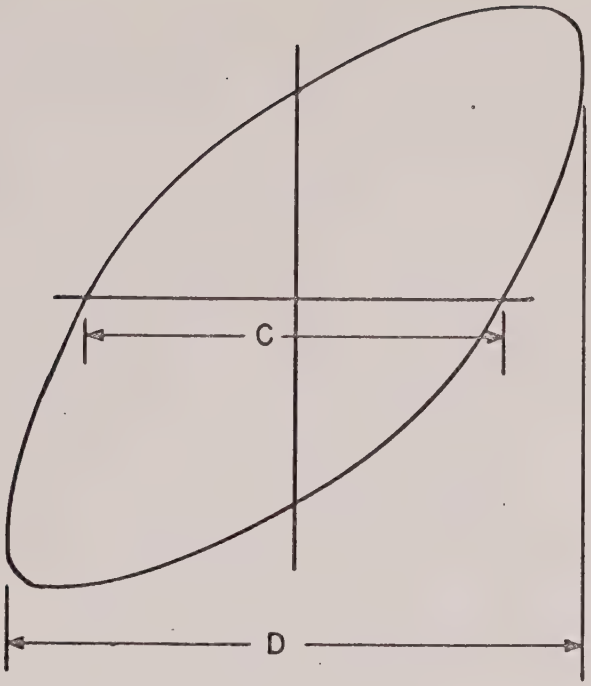


Fig. 6 Calculations of Phase Angle

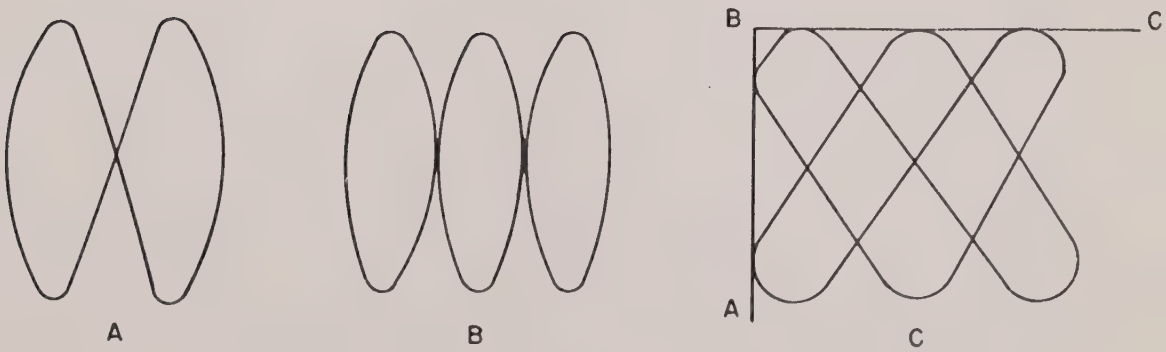


Fig. 7 Lissajous Figures Showing Frequency Differences

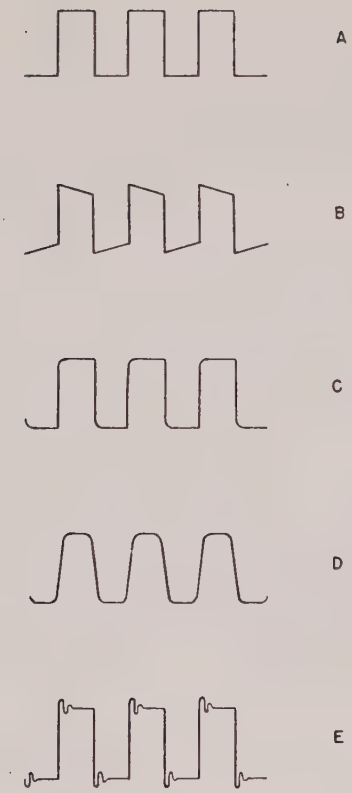


Fig. 8 Effects of Deficient Amplifiers on Square Waves

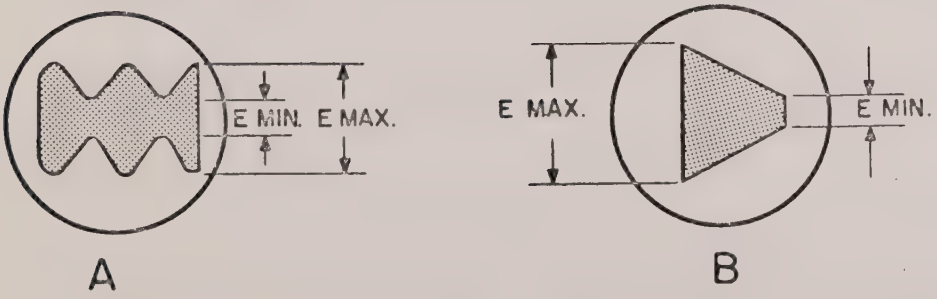


Fig. 9 Modulation Envelopes

7. DC MEASUREMENTS

Set the VERT SELECT switch to the DC position and connect the unknow voltage to the VERT binding post. Rotate the HORIZ GAIN controls to the counterclockwise positions. This will leave a small spot (set intensity control to a minimum point to avoid burning the screen) on the screen of tube which will either rise or fall, depending upon the polarity of the applied d-c voltage. Turn the VERT GAIN control to the desired sensitivi setting. Turn the VERT SELECT switch to CAL. Set the CAL VOLTS switch the peak-to-peak voltage, which does not deflect the spot off the screen, The deflection produced by a known voltage can then be compared to the deflection produced by the unknown voltage. Since the deflection of the trace is linear, the percentage difference between the two deflections c easily be translated into voltage differences.

As an example, an unknown d-c voltage is applied between the VERT an GND posts and the VERT GAIN control is adjusted until the spot is deflect one inch from its original center position. It is found that a deflectio of one inch is obtained when calibrated at the 30-volt peak-to-peak position. Therefore, if 30 volts makes a vertical line of one inch and th unknown voltage which is being measured deflects the spot one inch, the unknown voltage must be the same as the calibrating voltage or 30 volts.

8. AC MEASUREMENTS

The same procedure is followed when measuring a-c voltages, but the a-c voltage applied to the VERT and GND posts will cause the spot to trac a vertical line. A sine wave, for example, will produce a vertical line whose mid-point will be the original center position of the spot.

As pointed out previously, the total deflection produced by an a-c voltage is equal to the peak-to-peak value of the voltage. Thus, if a sine wave is being measured and a comparison against the calibrating volt age indicates a deflection equal to a voltage of ten volts, the peak-to peak value of the a-c signal is ten volts. A conventional rectifier typ a-c voltmeter connected across this same source of a-c voltage will ind cate the RMS value of voltage which is equal to $\frac{\text{E peak-to-peak}}{2} \times .707$, 3.54 volts. This difference should be borne in mind when a-c voltages a measured on the oscilloscope.

9. MEASUREMENT OF CURRENT

Although the oscilloscope is primarily an indicator of circuit volt it can be used to observe current changes by connecting a low-valued kno resistance in series with the circuit of the current to be analyzed. Changes in current flow will cause variation in the voltage drop across the resistor in accordance with Ohm's law. The voltage is then applied the instrument and current values can be calculated from the simple for $I = \frac{E}{R}$.

10. SQUARE WAVE TESTING OF AUDIO CIRCUITS

The visual checking of the response of an audio circuit by applying a rectangular wave to the input and observing the output waveform offers an efficient and easy method of determing the fidelity of that circuit.

If the apparatus is equipped with variable compensations for phase shift and high-frequency emphasis, it can be accurately adjusted for optimum response.

In the majority of cases two frequencies of square waves will determine the performance of the amplifier under test. One frequency should be low enough to test the low-frequency phase shift, and the other should be high enough to show the high-frequency response. A low-frequency square wave indicates on Fig. 8A, a good low-frequency response, and Fig. 8B, too small coupling capacitors. Feeding in a high-frequency wave of Fig. 8A shows a correctly compensated amplifier, Fig. 8C, with steep sides showing good high-frequency response, but excessive damping in the rounded corners. On Fig. 8D, the sloping sides show high-frequency attentuation, and the square tops show high damping and constant delay in the circuit. Fig. 8E, shows excessive high-frequency gain or under-damping of circuit.

In square wave testing, it is well to remember that loading a square wave generator with high capacity input amplifier circuits will change the input waveform. In such cases check the input wave and take any distortion into consideration when checking the output waveform.

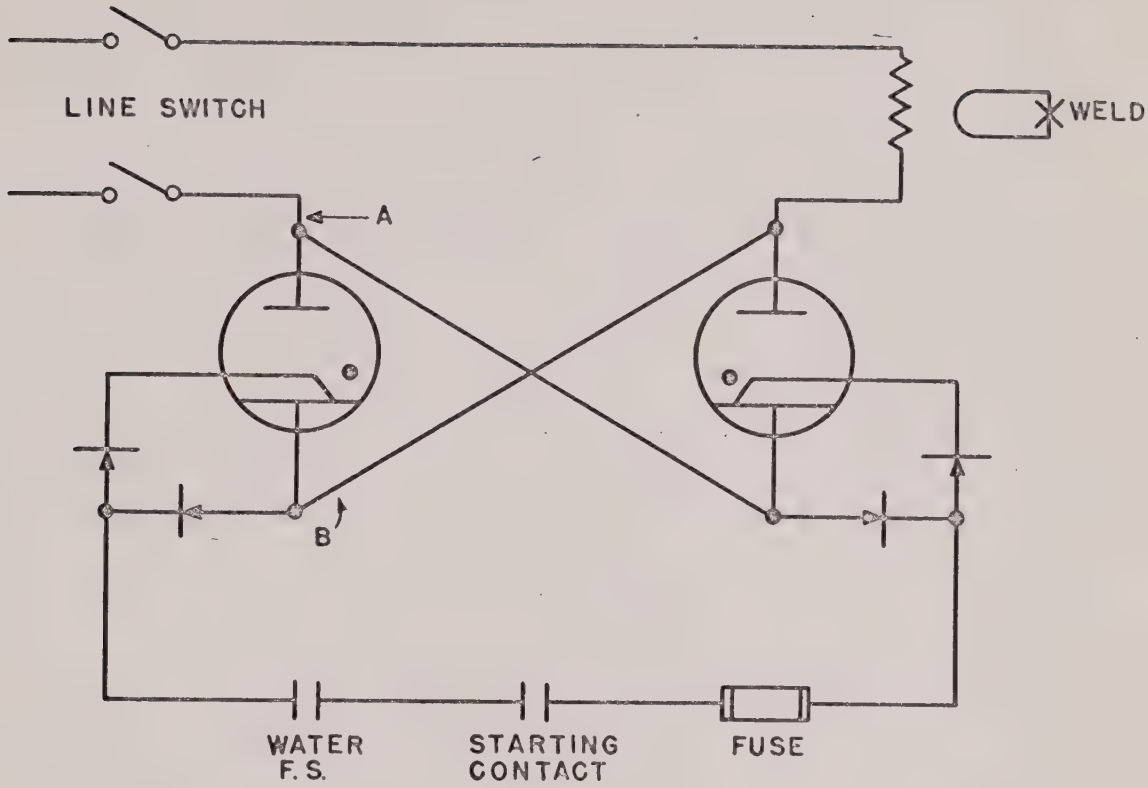
11. MEASURING PERCENTAGE MODULATION

By applying a modulated wave to the vertical plates of the cathode-ray tube, it is possible to measure the percentage modulation of the wave. There are two methods available; (1) by using the internal sawtooth sweep for time base reference; (2) by using the modulating wave as the sweep voltage (horizontal deflection).

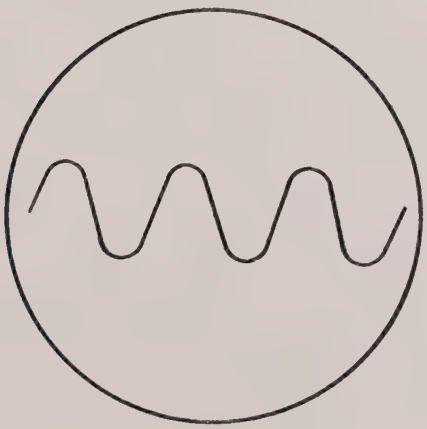
Using the linear sawtooth sweep produces a picture of the modulated wave (Fig. 9A). The percentage modulation can be calculated by the following equation:

$$\text{Percent Modulation} = \frac{E_{max.} - E_{min.}}{E_{max.} + E_{min.}} \times 100$$

When the modulating voltage is used as the horizontal sweep, the pattern is found to be as on Fig. 9B. This picture has an advantage over the other in that distortion and phase shift may be found by observing the deviation of the sloping sides from a straight line. Curved sides indicate distortion, while elliptical sides indicate phase shift. The percentage modulation may be calculated by measuring E max. and E min. and substituting in the previous equation.



A



B

Fig. 10 Welding Equipment Circuit and Waveforms

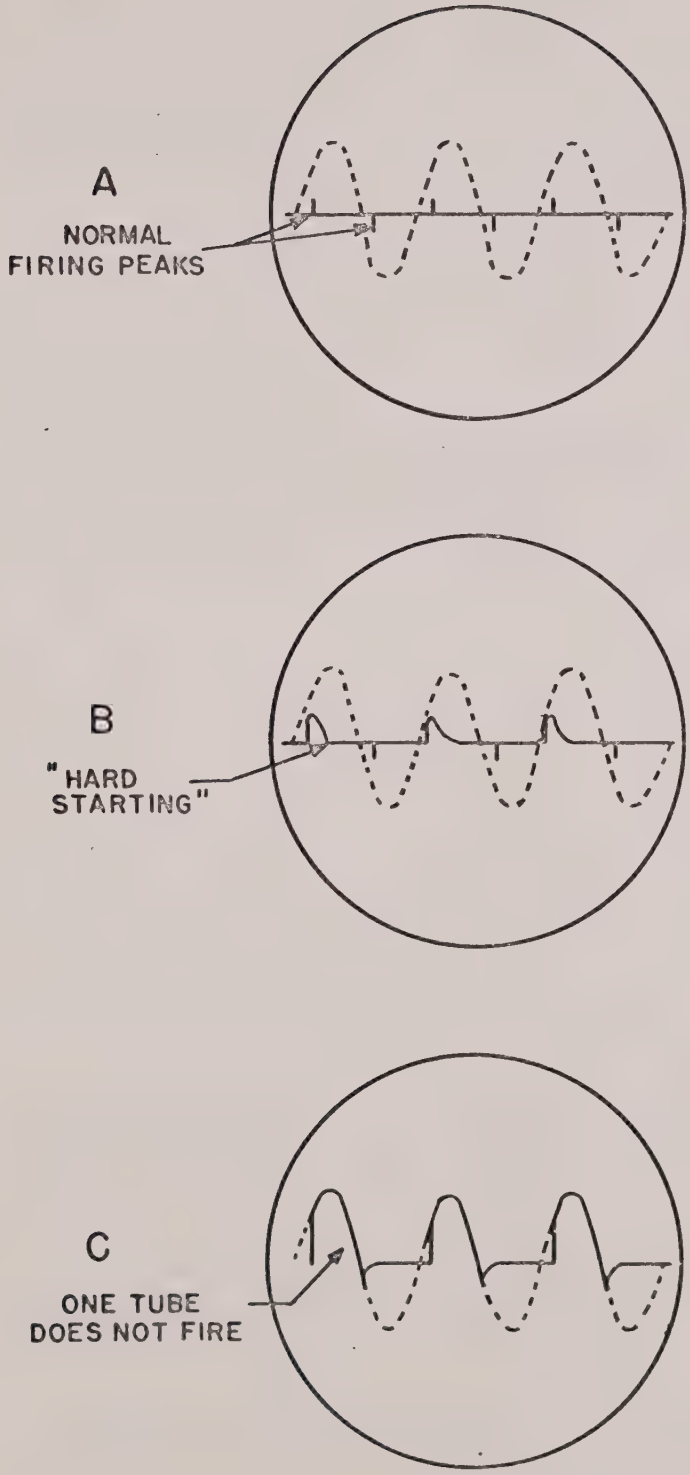


Fig. 11 Firing Cycle of Ignitron

12. TROUBLE SHOOTING BY WAVEFORM OBSERVATION

In order to be sure that a faithful reproduction of a given circuit waveform is to be obtained, two points in particular should be observed. First, the high-frequency response of the scope must be sufficient to pass the highest frequency component of the wave being studied. Second, the resistance or capacitance loading of the scope should not alter the operation of the circuit or alter the shape of the waveform.

A low-capacity probe (10 mmfd) is available for use with the ST-2B. This makes it possible to connect the probe directly to many points in the circuit without fear of excessive capacity loading. In some instances, the manufacturer recommends use of an additional series resistor for further isolation.

Since the expected waveforms in various parts of the circuit are usually given in the service data books provided by the manufacturer, it is possible to compare these waveforms with those actually obtained in the equipment at hand. Thus, one is provided with a very convenient means of checking for trouble or improper circuit operation.

13. CHECKING FIRING OF IGNITRON TUBES IN RESISTANCE WELDERS

Perhaps the simplest and most valuable use of the Oscilloscope on welder controls is checking the firing of ignitron tubes. Fig. 10A shows a basic ignitron contactor circuit.

Connect the VERT and GND posts to points A and B respectively, and set the VERT SELECT switch to the AC position. With the line switch on the welder control closed and the weld starting contact open, adjust the oscilloscope controls to show three to five full cycles of a-c voltage on the screen as shown on Fig. 10B.

When the starting contact closes and the tubes fire, the a-c waves will disappear except for small voltage peaks, as shown on Fig. 11A.

If one of the ignitron tubes is "hard-starting", the small voltage peaks will be enlarged as shown on Fig. 11B, indicating that a greater amount of voltage is being applied before the tube fires. Failure of one of the tubes to fire will be indicated by a partial wave as shown on Fig. 11C.

If the ignitrons are controlled by a phase-shifting (heat control) circuit, the curves shown may not apply except at 100 percent heat. A "hard-starting" ignitron is most easily seen, therefore, when the heat dial is at 100 percent.

14. CHECKING ARC-DROP OF THYRATRONS

Many industrial equipments employ thyratron tubes for control purposes because these tubes act as sensitive "trigger" devices which can be "fired" by relatively small control voltages.

The most important operating characteristic of these tube types is the "arc-drop", or the internal resistance of the tube when it is fired. This can quickly be checked by connecting the VERT and GND posts of the oscilloscope to the plate and cathode respectively of the thyratron, setting the VERT SELECT switch to AC, and adjusting the oscilloscope sweep circuits for three to five full cycles while the tube is not firing. When the tube fires, its arc-drop will be indicated by the collapse of the a-c waves as shown on Fig. 12.

15. MEASURING ARC-DROP OF THYRATRONS

The arc-drop patterns shown on Fig. 12 can easily be converted into volts by taking advantage of the calibrating voltage available in the ST-2B.

Set the VERT GAIN switch to a position of suitable attenuation and adjust the vernier gain control until the height of the arc-drop is an even number of divisions on the ruled scale. Substitute the calibrated voltage input in place of the signal. Set the CAL VOLTS switch to a suitable voltage within the screen boundaries. The deflection produced by this calibrating voltage can then be compared to the arc drop deflection and converted to volts as described in section 6, under Measurement of Voltage.

16. CYCLE COUNTING IN RESISTANCE WELDERS

An important use of the Oscilloscope is as a cycle counter in resistance welders. Since, in some applications, the total time taken for one weld is only a few cycles, it is advantageous to be able to check the adjustment of the equipment to insure that the time cycle is correct.

When only a few cycles are required per weld, the number can be observed directly by connecting the oscilloscope vertical input leads to the anode and cathode of the power tubes. Set the horizontal sweep circuit to give six or more cycles on the screen. The number of cycles the power tubes fire will be indicated by the voltage collapsing for that length of time and a straight line appearing on the screen instead of the a-c waveform.

17. OTHER APPLICATIONS

The following list of additional applications of the ST-2B Oscilloscope in the industrial field is presented primarily to acquaint the user with the possibilities and potential uses for an equipment of this type. This list is by no means complete because it would be impossible to enumerate the uses to which an oscilloscope can be put in the various branches

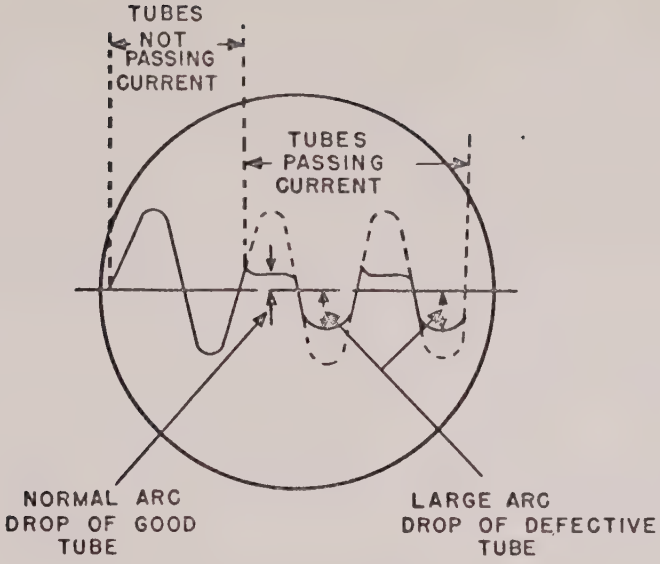


Fig. 12 Arc Drop Display

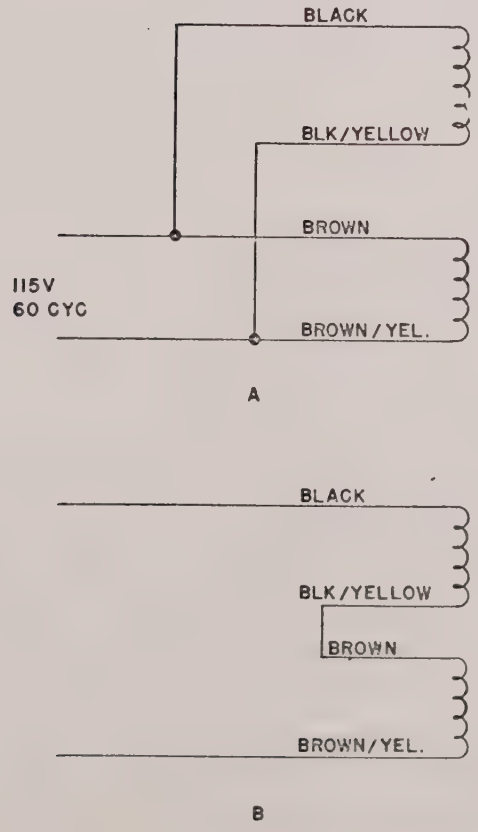


Fig. 13 Changes for 230-Volt Operation

of electronics.*

A. Checking for stray pick-up in photo-electric amplifiers.

B. Measuring ripple magnitude in photo-electric amplifiers.

C. Obtaining characteristic curves of high vacuum tubes.

D. Checking for contact bounce on relays and contactors.

E. Measuring angle of firing of thyratron and ignitrons.

F. Checking peaking transformer wave shapes.

G. Determining phasing and voltage relationships in Delta and Wye connected transformers.

MAINTENANCE

CAUTION

Since high voltages (2,000 volts) are present in the instrument, extreme caution should be exercised in trouble shooting and servicing. It is advisable to discharge capacitors C49 and C54 (mounted upright on the rear of the chassis) to ground using an insulated handle screwdriver.

1. TROUBLE-SHOOTING SUGGESTIONS

If the instrument appears entirely dead, check power fuse. If this is blown, try a new fuse (of the same size). If it blows immediately, the cause should be located before applying power again. The Oscilloscope is fused as lightly as possible for maximum protection, hence it is quite possible that under normal conditions of use the fuse may occasionally blow.

The most common source of trouble can usually be traced to tubes, hence these should be checked first and defective ones replaced.

B+ levels should be checked against the values given on the Elementary Diagram, Fig. 14, and the socket voltage chart. These values are nominal and will vary with conditions. As a general rule, the measured values should be within ±20% of the indicated values.

*Further information on uses of the oscilloscope in Industrial electronics can be found in the following publications:

"The Cathode Ray Oscillograph in Industrial Electronic Circuits". Delmar Publishers Inc., Broadway & Orange St., Albany, N. Y.

"Electronic Control of Resistance Welding" by G. M. Chute. McGraw Hill Book Company, 330 West 42nd St., New York, N. Y.

2. PANEL ADJUSTMENT

A. Vertical Balance

VERT BALANCE (R10) is a screwdriver control located on the front panel. It is used to adjust the screen voltages of V1 and V2 so that the plate voltages are equal. This is necessary to prevent the beam from moving as the VERT GAIN control is adjusted. The procedure is as follows:

1) Set the VERT GAIN vernier control to minimum.

2) Position the beam to exact center of the screen by means of the VERT POSITION control.

3) Rotate the VERT GAIN vernier control to maximum, and adjust VERT BALANCE control to recenter the beam.

4) Repeat steps 1), 2), and 3) a second time if necessary. Proper adjustment is indicated when, with no d-c signal being fed to the input, the beam will not move with a change in the setting of the GAIN control.

B. Horizontal Balance

The HORIZ BALANCE control (R44) serves the same function for the horizontal gain control as R10 does for the vertical gain control. It is set in the same manner, using the HORIZ POSITION control to center the beam. The HORIZ SELECT switch should be set in the AC or DC positions, with no signal present on the input binding posts.

3. CHASSIS ADJUSTMENTS

A. Sweep Hold

The SWEEP HOLD control (R71) determines the amount of bias on the 884 tube, and may need adjustment from time to time to improve the operation of either the triggered or recurrent sweep.

1) Set the sweep frequency range selector on 60/250 position and the SWEEP TRIG-RECUR switch to RECUR. Adjust the HORIZ GAIN control for approximately 2 inches of horizontal deflection.

2) Turn the SWEEP switch to the TRIG position (no synchronizing signal applied) and adjust the SWEEP HOLD control so that the spot rests approximately 1 inch to the right of the right-hand excursion of the trace obtained in the adjustment of step 1).

This adjustment affects the sweep frequency somewhat, and it will change the d-c level of the sweep output. This second effect is corrected by resetting the SWEEP LEVEL control (R74).

B. Sweep Level

Since the horizontal amplifier is direct-coupled, and direct coupling is employed from the sweep generator to the horizontal amplifier, it is necessary to adjust the d-c level of the sweep generator output to zero. This is done by adjusting R74, the SWEEP LEVEL control.

1) First make sure that the HORIZ BALANCE control has been set correctly; center the trace then turn the HORIZ SELECT switch to one of the sync positions (INT + or -).

2) Set the sweep frequency range selector switch to 60/250 position, and adjust the horizontal gain to give approximately 2 inches of deflection.

3) Adjust R74 to recenter the trace horizontally if necessary.

C. Linearity and Bias Adjustments

Two potentiometers R56, HORIZ LINEARITY and R43 HORIZ BIAS (or R22 VERT LINEARITY and R9 VERT BIAS), are employed in each amplifier to allow for necessary adjustments in d-c levels due to variations caused by tube ageing and tube replacements.

Normally, these potentiometers will need adjustment when non-linearities are noted in the amplifiers. The test for nonlinearity is as follows: Using a frequency below 10 kc (or use the calibration voltages), obtain a two-inch trace on the screen. Center the trace (vertically or horizontally, as the case may be), with the proper positioning control. Holding the input voltage and the gain constant, move the trace endwise by means of the positioning control, one inch in each direction (total excursion 4 inches). The trace should remain 2 inches long (within 10%) at any position. If the linearity is poor, adjust the VERT LINEARITY (R22 or HORIZ LINEARITY R56) control slightly until good linearity is obtained. The vertical adjustment should be performed first as it determines the amount of negative bias on the negative bus and hence affects both amplifiers to some degree.

If it is found that the amplifiers are completely out of adjustment, then proceed as follows:

1) Vertical Amplifier

Always adjust this amplifier first.

By means of VERT BIAS (R9) and VERT LINEARITY (R22), adjust the plate voltage of V1 or V2 to 31 volts, and the plate voltage of V3 to 105 volts. The adjustment of either control interacts with the other, therefore several adjustments may be necessary between the two before both plate voltages are correct. Be sure to use a vacuum-tube voltmeter to monitor the plate voltage. Do not attempt to use a multimeter with a 20,000 ohm/volt movement as the resultant loading will give erroneous results.

After the BIAS and LINEARITY controls have been adjusted, recheck and readjust the linearity as described in the first paragraph.

2) Horizontal Amplifier

Always adjust the vertical amplifiers first.

By means of HORIZ BIAS (R43) and HORIZ LINEARITY (R56), adjust the plate voltage of V5 or V6 to 31 volts, and the plate voltage of V7 to 105 volts. The adjustment of either control interacts with the other, therefore several adjustments may be necessary between the two before both plate voltages are correct. Be sure to use a vacuum-tube voltmeter to monitor the plate voltage. Do not try to use a multimeter with a 20,000 ohms/volt movement.

After the BIAS and LINEARITY controls have been adjusted, recheck and readjust the linearity as described in the first paragraph.

D. Frequency Alignment (Amplifiers)

From time to time, particularly when tubes are replaced, it may be necessary to realign the amplifiers for proper frequency response. This may be done as follows:

1) Vertical Amplifiers

a) Set the vertical attenuator control (S1) to the times 1 position, and the vernier gain control to minimum.

b) Feed a 10 kc square wave to the vertical input binding posts and adjust the square wave generator to give approximately two inches of deflection.

c) Adjust trimmers C12 and C13 by equal amounts until the square wave pattern just starts to show peaking.

d) Set the vernier gain control to maximum and reduce the input to again produce a two-inch deflection.

e) Adjust trimmers C9 and C10 by equal amounts until the square wave pattern just starts to peak.

2) Horizontal Amplifiers

The horizontal amplifiers are aligned in much the same manner; however, to display the square wave on the horizontal amplifier it is first necessary to provide a time base (saw-tooth sweep) on the vertical axis. This can be done by turning the HORIZ SELECT switch to SET. This turns the sweep generator and horizontal amplifier on, but instead of feeding the sweep to the horizontal amplifier, it is fed to the CAL VOLTS switch (S10). Set the CAL VOLTS switch to the SW SIG position, and set the VERT SELECT switch to CAL. The sweep is now fed to the

vertical amplifier and the horizontal amplifier input binding post may be connected to the output of the square wave generator. The sweep may be synchronized by feeding a sample of the square wave by means of a clip load, to the top of C30. This is located back of the sync amplitude control. The alignment procedure is then as follows:

a) Set the horizontal attenuator control (S3) to the times 1 position, and the vernier gain control to minimum.

b) Feed a 10 kc square wave to the horizontal input binding post, and adjust the square wave generator to give approximately two inches of deflection.

c) Adjust trimmers C27 and C28 by equal amounts until the square wave pattern just starts to show peaking.

d) Set the vernier gain control to maximum and reduce the input signal to again produce a two-inch deflection.

e) Adjust trimmers C24 and C25 by equal amounts until the square wave pattern just starts to peak.

3) Alignment for Critical Phase Measurements

If phase measurements are to be made utilizing both amplifiers, an additional step in alignment should be performed after completing the procedure outlined in sections 1) and 2) above.

a) Feed a sine wave signal of 300 kc into both amplifiers.

b) Set both attenuators to the times 1 position.

c) With both vernier controls set to minimum, readjust trimmers C27 and C28 slightly (if necessary) to reduce phase shift to zero.

d) Set both vernier controls to maximum, and readjust trimmers C24 and C25 for zero phase shift.

With this alignment there will be a negligible amount of phase shift between the amplifiers for frequencies below 300 kc. Best results will be obtained on phase measurements if the two vernier gain controls are kept at comparable settings. This is especially true at frequencies above 50 kc.

E. Frequency Alignment (Attenuators)

1) Vertical Attenuator

To adjust the compensating capacitors in the vertical attenuator the following procedure should be used:

a) Feed a 10 kc square wave into the vertical input binding posts.

b) Set attenuator on times 1/10 position and adjust C7, located on S1, for best square wave.

c) Similarly, set attenuator on 1/100 position, and adjust C6.

d) Set attenuator on 1/1000 position and adjust C5.

2) Probe

The probe is aligned in the following manner:

a) Feed the 10 kc square wave into the probe.

b) Set the vertical attenuator to the times 1/10 position, and adjust C15, located on the terminal board, for best square wave.

c) Switch the attenuator to the times 1 position, and adjust C4 for the best square wave.

3) Horizontal Attenuator

To adjust the compensating capacitors in the horizontal attenuator the following procedure should be used:

a) Switch the sweep to the vertical amplifier as described in section D 2) above. (Turn HORIZ SELECT to SET, CAL VOLTS to SW SIG, and VERT SELECT to CAL.)

b) Feed a 10 kc square wave into the horizontal input binding posts.

c) Set the attenuator on times 1/10 position and adjust C22, located on S3, for best square wave.

d) Set the attenuator on 1/100 position, and adjust C21.

e) Set attenuator on 1/1000 position, and adjust C20.

4) Phase Measurements

If the Oscilloscope is to be used for phase measurements utilizing both amplifiers, it is advisable to readjust C22, C21 and C20 slightly as may be determined by feeding like signals to both horizontal and vertical amplifiers.

4. CHANGES FOR 230-VOLT OPERATION (See Fig. 13)

The transformer is supplied with two primaries so that it can be used for either 117-or 230-volt power line voltage. The instrument is factory wired for 117-volt operation, with the two primaries wired in parallel. For 230-volt operation, the primaries should be rewired in series. Clip the black lead and the brown-yellow lead at approximately 3 inches from the transformer. Splice the two transformer leads together and tape. Tape the other two ends that go to the power switch and fuse post separately and leave them in the cable.

5. PROVISION FOR EXTREMELY SLOW SWEEP

Pin jacks J6 and J7 located on the front panel marked EXT CAP may be used to provide sweep speeds as low as desired. Set the sweep frequency range switch (S6) to EXT and place an oil-filled (not an electrolytic) capacitor across the pin jacks. By increasing the size of the capacitor a slower and slower sweep may be obtained.

6. SOCKET VOLTAGE DATA

Socket voltage data is given in the Socket Voltage Chart. Average values are given, and some variation is to be expected between instruments due to manufacturing and component tolerances.

All d-c voltages measured to ground.

DC voltages measured with a VTVM (not a 20,000 ohms-per-volt instrument).

AC voltages measured between points indicated with 1000 ohms-per-volt instrument.

Voltage given is when control is set to a normal position.

SOCKET VOLTAGE CHART

	V1	V2	V3
Pin 1	0	0	105
2	0	0	31
3	3.5	3.5	32
4	68 (6.3 a-c)	68 (6.3 a-c)	68 (6.3 a-c)
5	68	68	68
6	0	0	105
7	108	108	31
8	31	31	32
9	3.5	3.5	0

SOCKET VOLTAGE CHART (CONTINUED)

V4

Pin	
1	260
2	105
3	107
4	68
5	68
6	260
7	105
8	110
9	0

(6.3 a-c)

V5

Pin	
1	0
2	0
3	3.5
4	68
5	68
6	0
7	108
8	31
9	3.5

(6.3 a-c)

V6

Pin	
1	0
2	0
3	3.5
4	68
5	68
6	0
7	108
8	31
9	3.5

(6.3 a-c)

V7

Pin	
1	105
2	31
3	32
4	68
5	68
6	105
7	31
8	32
9	0

(6.3 a-c)

V8

Pin	
1	260
2	105
3	107
4	68
5	68
6	260
7	105
8	107
9	0

(6.3 a-c)

V9

Pin	
1	-30
2	68
3	+1 to -2
4	-30
5	-30
6	-30
7	68
8	-26

(6.3 a-c)

V10

Pin	
1	+0.6
2	-30
3	-29
4	68
5	68
6	+1 to -2
7	+1 to -2
8	+15
9	68

(6.3 a-c)

V11

Pin	
1	390
2	+1 to -2
3	+19 to +22
4	68
5	68
6	9
7	-30
8	-30
9	68

(6.3 a-c)

V12

Pin	
1	-1800
2	-1400 to -1800
3	-1400 to -1600
4	-800 to -1200
5	NC
6	260
7	260
8	260
9	260
10	260
11	NC
12	-1800

(6.3 a-c)

V13

Pin	
1	
2	
3	
4	
5	
6	-2250
7	
8	
TC	-2250

V14

Pin	
1	NC
2	450
3	NC-
4	0
5	0 (900 a-c) (5 a-c)
6	0
7	0
8	450

V15

Pin	
1	120
2	NC
3	+15
4	NC
5	NC
6	NC
7	-30

SOCKET VOLTAGE CHART (CONTINUED)

RT-1

Pin		
1	NC	
2	+68	(6.3 a-c)
3	+68	
4	NC	
5	-30	
6	+68	
7	+68	
8	NC	

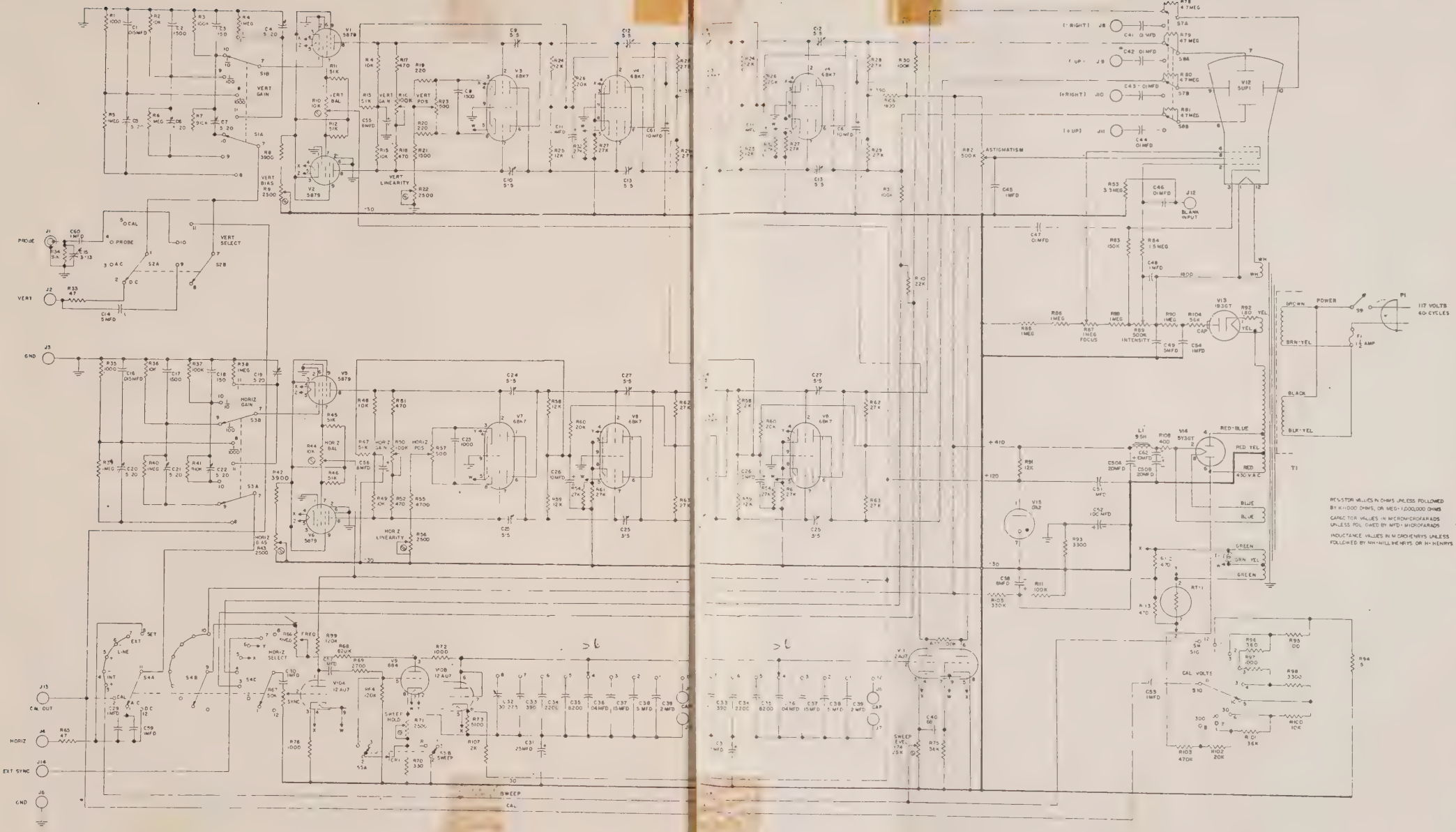


Fig. 14 Elementary Diagram, Oscilloscope, Type ST-2B, ... loscope, Type ST-2B, ... ision A (E-7354101, Rev. 4)

PARTS LIST

This list includes all principal replacement parts. The symbol numbers used are the same as those appearing on elementary and other diagrams. When ordering a replacement part, please include description, symbol designation, and reference number of the part and model number of the equipment. Orders may be sent to the nearest General Electric office or to the General Electric Company, Commercial and Government Equipment Department, Electronics Division, Syracuse, New York.

Symbol	Description	G-E Drawing
	CAPACITORS	
*C1	Paper, 0.015 mfd ± 10%, 400 v d-c w.	K-113J377-P2
*C2	Mica, Class B; 1500 mmfd ± 10%, 500 v d-c w. RTMA Type RCM30B152K.	P-3R139-P6
*C3	Mica, Class B; 150 mmfd ± 10%, 500 v d-c w. RTMA Type RCM20B151K.	P-3R141-P16
*C4 thru C7	Variable, ceramic, 5 to 20 mmfd, 500 v d-c w. Erie Type TS2A-N300.	M-7484389-P4
*C8	Mica, Class B; 1500 mmfd ± 10%, 500 v d-c w. RTMA Type RCM30B152K.	P-3R139-P6
*C9 and C10	Variable, ceramic, 0.50 to 5.0 mmfd, 500 v d-c w. Erie Type 532.	B-7485943-P4
*C11	Electrolytic, 10 mfd +75% -0%, 450 v d-c w. Cornell Dubilier Cat. #BR1045.	P-7768109-P22
*C12 and C13	Variable, ceramic, 0.50 to 5.0 mmfd, 500 v d-c w. Erie Type 532.	B-7485943-P4
C14	Paper, 0.5 mfd ± 20%, 600 v d-c w. Pyramid Elec. Type 85T0C6.	K-7119117-P3

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	CAPACITORS (CONTINUED)	
*C15	Variable, ceramic, 3-13 mmfd, 500 v d-c w. Erie Type TS2A-N300.	M-7484389-P3
*C16	Paper, 0.015 mfd ± 10%, 400 v d-c w.	K-113J377-P2
*C17	Mica, Class B; 1500 mmfd ± 10%, 500 v d-c w. RTMA Type RCM30B152K.	P-3R139-P6
*C18	Mica, Class B; 150 mmfd ± 10%, 500 v d-c w. RTMA Type RCM20B151K.	P-3R141-P16
*C19 thru C22	Variable, ceramic, 5 to 20 mmfd, 500 v d-c w. Erie Type TS2A-N300.	M-7484389-P4
*C23	Mica, Class B; 1000 mmfd ± 10%, 500 v d-c w. RTMA Type RCM30B102K.	P-3R139-P4
*C24 and C25	Variable, ceramic, 0.50 to 5.0 mmfd, 500 v d-c w. Erie Type 532.	B-7485943-P4
*C26	Electrolytic, 10 mfd +75% -0%, 450 v d-c w. Cornell Dubilier Cat.#BR1045.	P-7768109-P22
*C27 and C28	Variable, ceramic, 0.5 to 5.0 mmfd, 500 v d-c w.	B-7485943-P4
*C29 and C30	Paper, molded plastic, 0.10 mfd ± 20%, 600 v d-c w. Sprague Cat. #73P10406.	M-7481651-P53
*C31	Electrolytic, 25 mfd +100% -10%, 50 v d-c w.	M-7475376-P13
C32	Variable, mica, 30 to 273 mmfd. FW Sickles Type LC-D.	M-7478644-P26
*C33	Mica, Class B; 390 mmfd ± 10%, 500 v d-c w. RTMA Type RCM20B391K.	P-3R141-P21
*C34	Mica, Class B; 2200 mmfd ± 10%, 500 v d-c w. RTMA Type RCM30B222K.	C-3R139-P8

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	CAPACITORS (CONTINUED)	
*C35	Mica, Class B; 8200 mmfd ± 10%, 300 v d-c w. RTMA Type RCM35B822K.	C-3R139-P15
*C36	Paper, 0.04 mfd ± 10%, 400 v d-c w.	M-103J789-P34
*C37	Paper, 0.15 mfd ± 10%, 400 v d-c w.	M-103J789-P33
*C38	Paper, 0.50 mfd ± 10%, 400 v d-c w.	M-103J789-P15
*C39	Paper, metallized, 2.0 mfd ± 20%, 100 v d-c w. Aerovox Type 89Z.	C-7773757-P26
*C40	Mica, Class B; 68 mmfd ± 10%, 500 v d-c w. RTMA Type RCM20B680K.	P-3R141-P12
*C41 thru C44	Paper, molded plastic; 0.01 mfd ± 20%, 600 v d-c w. Sprague Cat. #73P10306.	M-7481651-P47
*C45	Paper, 0.10 mfd ± 10%, 600 v d-c w.	M-103J700-P23
*C46 and C47	Paper, metal case, 0.01 mfd ± 20%, 2000 v d-c w.	M-7476463-P12
*C48	Paper, 0.10 mfd ± 10%, 600 v d-c w.	M-103J700-P23
C49	Pyranol, 0.50 mfd ± 10%, 2000 v d-c w. G-E Cat. #23F380.	C-7773777-P2
*C50	Electrolytic, polarized, twist prong base; 20-20 mfd + 50% -10%, 450-450 v d-c w. Mallory Type FP234.	M-7473661-P3
*C51	Paper, 0.10 mfd ± 10%, 600 v d-c w.	M-103J700-P23
*C52	Electrolytic, 100 mfd +100% -10%, 50 v d-c w. Solar Cat. #M-50100.	K-102J782-P1
*C53	Paper, molded plastic; 0.10 mfd ± 20%, 600 v d-c w. Sprague Cat. #73P10406.	B-7481651-P53
C54	Pyranol, 0.10 mfd ± 10%, 2000 v d-c w. G-E Cat. #23F378.	C-7773777-P1

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	CAPACITORS (CONTINUED)	
*C55 and C56	Electrolytic, 8 mfd +100% -0%, 150 v d-c w. Cornell Dubilier Cat. #BR815.	P-7768109-P6
*C57	Paper, molded plastic; 0.10 mfd ± 20%, 400 v d-c w. Sprague Cat. #67P10404.	M-7481651-P33
*C58	Electrolytic, 8 mfd +100% -0%, 150 v d-c w. Cornell Dubilier Cat. #BR815.	P-7768109-P6
*C59	Paper, molded plastic, 0.10 mfd ± 20%, 600 v d-c w. Sprague Cat. #73P10406.	M-7481651-P53
C60	Paper, 1.0 mfd ± 20%, 100 v d-c w. Pyramid Elec. Type 85TOC1.	K-7119117-P2
*C61 and C62	Electrolytic, 10 mfd +75% -0%, 450 v d-c w. Cornell Dubilier Cat. #BR1045.	P-7768109-P22
	RECTIFIER	
*CR1	Diode, germanium. RTMA Type 1N48.	
	FUSES	
*F1	1 1/2 amp, 250 v, Type 3AG. Littelfuse Cat. #31201.5, Bussman Cat. #AGC-1 1/2.	K-1R16-P4
	INDICATING DEVICE	
*I1	Lamp: 6-8 v, 0.15 amp, miniature bayonet base. G-E Cat. #47.	
	JACKS AND RECEPTACLES	
*J1	Locknut receptacle. Amphenol Type PC1M less solder lug and fibre washers.	K-7113342-P2
*J2 thru J5	Binding posts, black. Superior Elec. Type DF30BC.	K-107J146-P1

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	JACKS AND RECEPTACLES (CONTINUED)	
*J6 and J7	Tip Jacks: black head. E F Johnson Type 105-521-15.	K-7108472-P2
*J8 thru J14	Binding posts, black. Superior Elec. Type DF30BC.	K-107J146-P1
	INDUCTORS	
L1	Choke, filter: d-c resistance 370 ohms max. Freed Transformer Co. Cat. #13342.	M-103J75-P1
	RESISTORS	
R1	Composition, 1000 ohms ± 5%, 1/2 w. Jan Type RC20GF102J.	
R2	Composition, 10,000 ohms ± 5%, 1/2 w. Jan Type RC20GF103J.	
R3	Composition, 0.10 megohm ± 5%, 1/2 w. Jan Type RC20GF104J.	
R4 thru R6	Composition, 1.0 megohm ± 5%, 1/2 w. Jan Type RC20GF105J.	
R7	Composition, 0.91 megohm ± 5%, 1/2 w. Jan Type RC20GF914J.	
*R8	Composition, 3900 ohms ± 10%, 1/2 w. Jan Type RC20GF392K.	
*R9	Potentiometer, wirewound: 2500 ohms ± 10%, linear taper, 2 w.	M-2R72-P62
*R10	Potentiometer, composition: 10,000 ohms ± 20%, linear taper, 1/2 w.	B-2R75-P54
R11 thru R13	Composition, 51,000 ohms ± 5%, 1/2 w. Jan Type RC20GF513J.	

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	RESISTORS (CONTINUED)	
*R14 and R15	Carbon film on ceramic, 10,000 ohms ± 1%, 1/2 w.	C-7707244-P485
R16	Potentiometer: 100,000 ohms ± 20%, 1/2 w. Part of S1.	
*R17 and R18	Composition, 470 ohms ± 10%, 1/2 w. Jan Type RC20GF471K.	
*R19 and R20	Composition, 220 ohms ± 10%, 1/2 w. Jan Type RC20GF221K.	
*R21	Composition, 1500 ohms ± 10%, 1/2 w. Jan Type RC20GF152K.	
*R22	Potentiometer, wirewound: 2500 ohms ± 10%, linear taper, 2 w.	M-2R72-P62
*R23	Potentiometer, composition: 500 ohms ± 20%, linear taper, 1/2 w.	B-2R75-P6
R24 and R25	Composition, 12,000 ohms ± 5%, 2 w. Jan Type RC42GF123J.	
*R26	Wirewound, 20,000 ohms ± 5%, 10 w. Sprague Type 10 KT with pigtail terminals.	M-7478740-P44
*R27	Composition, 27,000 ohms ± 10%, 2 w. Jan Type RC42GF273K.	
R28 and R29	Composition, 27,000 ohms ± 5%, 2 w. Jan Type RC42GF273J.	
*R30 and R31	Composition, 0.10 megohm ± 10%, 1/2 w. Jan Type RC20GF104K.	
*R32	Composition, 27,000 ohms ± 10%, 2 w. Jan Type RC42GF273K.	

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	RESISTORS (CONTINUED)	
*R33	Composition, 47 ohms ± 10%, 1/2 w. Jan Type RC20GF470K.	
R34	Composition, 91,000 ohms ± 5%, 1/2 w. Jan Type RC20GF913J.	
R35	Composition, 1000 ohms ± 5%, 1/2 w. Jan Type RC20GF102J.	
R36	Composition, 10,000 ohms ± 5%, 1/2 w. Jan Type RC20GF103J.	
R37	Composition, 0.10 megohm ± 5%, 1/2 w. Jan Type RC20GF104J.	
R38 thru R40	Composition, 1.0 megohm ± 5%, 1/2 w. Jan Type RC20GF105J.	
R41	Composition, 0.91 megohm ± 5%, 1/2 w. Jan Type RC20GF914J.	
*R42	Composition, 3900 ohms ± 10%, 1/2 w. Jan Type RC20GF392K.	
*R43	Potentiometer, wirewound: 2500 ohms ± 10%, 2 w, linear taper.	M-2R72-P62
*R44	Potentiometer, composition: 10,000 ohms ± 20%, 1/2 w, linear taper.	M-2R75-P54
R45 thru R47	Composition, 51,000 ohms ± 5%, 1/2 w. Jan Type RC20GF513J.	
*R48 and R49	Carbon film on ceramic, 10,000 ohms ± 1%, 1/2 w.	C-7707244-P485
R50	Potentiometer: 100,000 ohms ± 20%, 1/2 w. Part of S3.	
*R51 and R52	Composition, 470 ohms ± 10%, 1/2 w. Jan Type RC20GF471K.	

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	RESISTORS (CONTINUED)	
*R53	Composition, 3.3 megohm ± 10%, 1/2 w. Jan Type RC20GF335K.	
*R54	Composition, 27,000 ohms ± 10%, 2 w. Jan Type RC42GF273K.	
*R55	Composition, 4700 ohms ± 10%, 1/2 w. Jan Type RC20GF472K.	
*R56	Potentiometer, wirewound: 2500 ohms ± 10%, 2 w, linear taper.	M-2R72-P62
*R57	Potentiometer, composition: 500 ohms ± 20%, 1/2 w, linear taper.	B-2R75-P6
R58 and R59	Composition, 12,000 ohms ± 5%, 2 w. Jan Type RC42GF123J.	
*R60	Wirewound, 20,000 ohms ± 5%, 10 w. Sprague Type 10 KT with pigtail terminals.	M-7478740-P44
*R61	Composition, 27,000 ohms ± 10%, 2 w. Jan Type RC42GF273K.	
R62 and R63	Composition, 27,000 ohms ± 5%, 2 w. Jan Type RC42GF273J.	
*R64	Composition, 0.12 megohm ± 10%, 1/2 w. Jan Type RC20GF124K.	
*R65	Composition, 47 ohms ± 10%, 1/2 w. Jan Type RC20GF470K.	
R66	Potentiometer: 5.0 megohm ± 20%, 1/2 w. Part of S6.	
*R67	Potentiometer, composition: 50,000 ohms ± 20%, 1/2 w, linear taper.	B-2R75-P18
*R68	Composition, 0.82 megohm ± 10%, 1/2 w. Jan Type RC20GF824K.	

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	RESISTORS (CONTINUED)	
*R69	Composition, 2700 ohms ± 10%, 1/2 w. Jan Type RC20GF272K.	
*R70	Composition, 330 ohms ± 10%, 1/2 w. Jan Type RC20GF331K.	
*R71	Potentiometer, composition: 2500 ohms ± 20%, 1/2 w, linear taper.	B-2R75-P50
*R72	Composition, 1000 ohms ± 10%, 1/2 w. Jan Type RC20GF102K.	
R73	Composition, 5100 ohms ± 5%, 1/2 w. Jan Type RC20GF512J.	
*R74	Potentiometer, composition: 25,000 ohms ± 20%, 1/2 w, linear taper.	B-2R75-P56
*R75	Composition, 56,000 ohms ± 10%, 1/2 w. Jan Type RC20GF563K.	
*R76	Composition, 1000 ohms ± 10%, 1/2 w. Jan Type RC20GF102K.	
*R77	Composition, 0.10 megohm ± 10%, 2 w. Jan Type RC42GF104K.	
*R78 thru R81	Composition, 4.7 megohm ± 10%, 1/2 w. Jan Type RC20GF475K.	
*R82	Potentiometer, composition: 500,000 ohms ± 20%, 1/2 w, linear taper.	B-2R75-P24
*R83	Composition, 0.15 megohm ± 10%, 1/2 w. Jan Type RC20GF154K.	
*R84	Composition, 1.5 megohm ± 10%, 1/2 w. Jan Type RC20GF155K.	
*R85 and R86	Composition, 1.0 megohm ± 10%, 1/2 w. Jan Type RC20GF105K.	
R87	Potentiometer, composition: 1.0 megohm ± 20%, 1/4 w, linear taper. Clarostat Series 37 with Series 60 high voltage Coupler.	K-102J565-P5

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	RESISTORS (CONTINUED)	
*R88	Composition, 1.0 megohm ± 10%, 1/2 w. Jan Type RC20GF105K.	
R89	Potentiometer, composition: 500,000 ohms ± 20%, 1/4 w, linear taper. Clarostat Series 37 with Series 60 high voltage coupler.	K-102J565-P6
*R90	Composition, 1.0 megohm ± 10%, 1/2 w. Jan Type RC20GF105K.	
R91	Wirewound, 12,000 ohms ± 5%, 25 w. Ward Leonard Cat. #K41383-2.	M-2R14-P92
*R92	Wirewound, 1.80 ohm ± 10%, 1/2 w.	P-3R18-P11
R93	Composition, 3300 ohms ± 5%, 1/2 w. Jan Type RC20GF332J.	
R94	Composition, 51 ohms ± 5%, 1/2 w. Jan Type RC20GF510J.	
R95	Composition, 100 ohms ± 5%, 1/2 w. Jan Type RC20GF101J.	
R96	Composition, 360 ohms ± 5%, 1/2 w. Jan Type RC20GF361J.	
*R97	Composition, 1000 ohms ± 5%, 1/2 w. Jan Type RC20GF102J.	
R98	Composition, 3300 ohms ± 5%, 1/2 w. Jan Type RC20GF332J.	
*R99	Composition, 0.12 megohm ± 10%, 1 w. Jan Type RC30GF124K.	
R100	Composition, 10,000 ohms ± 5%, 1/2 w. Jan Type RC20GF103J.	
R101	Composition, 36,000 ohms ± 5%, 1/2 w. Jan Type RC20GF363J.	
R102	Composition, 0.12 megohm ± 5%, 1/2 w. Jan Type RC20GF124J.	

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	RESISTORS (CONTINUED)	
R103	Composition, 0.47 megohm ± 5%, 1/2 w. Jan Type RC20GF474J.	
*R104	Composition, 56,000 ohms ± 10%, 1/2 w. Jan Type RC20GF563K.	
*R105	Composition, 0.33 megohm ± 10%, 1/2 w. Jan Type RC20GF334K.	
*R106	Composition, 1800 ohms ± 10%, 1/2 w. Jan Type RC20GF182K.	
R107	Composition, 12,000 ohms ± 5%, 2 w. Jan Type RC42GF123J.	
R108	Wirewound, 400 ohms ± 5%, 10 w. Ward Leonard Cat. #K41382-2.	M-2R12-P77
*R109 and R110	Composition, 22,000 ohms ± 10%, 1/2 w. Jan Type RC20GF223K.	
*R111	Composition, 0.10 megohm ± 10%, 1/2 w. Jan Type RC20GF104K.	
*R112 and R113	Composition, 470 ohms ± 10%, 1/2 w. Jan Type RC20GF471K.	
	BALLEST RESISTOR	
RT1	Resistor, ballast. Amperite Type 6-4.	K-7116518-P1
	SWITCHES	
S1	Rotary switch: 2 sections, 4 positions, 1 pole per section with potentiometer R16 included. Oak Type N or Grigsby-Allison Type 4M-LW.	C-7773767-P1
S2	Rotary switch: 1 section, 4 positions, 2 pole. Oak Type N or Grigsby-Allison Type 4M-LW.	C-7773767-P2

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	SWITCHES (CONTINUED)	
S3	Rotary switch: 2 sections, 4 positions, 1 pole per section with potentiometer R50 included. Oak Type N or Grigsby-Allison Type 4M-LW.	C-7773767-P1
S4	Rotary switch: 2 sections, 9 positions. Oak Type N or Grisby-Allison Type 4M-LW.	C-7773767-P3
S5	Rotary switch: Similar to Centralab Type 6BX. Nonshorting type contacts, 2 positions.	A-7140192-P1
S6	Rotary switch: 2 sections, 9 positions, 1 pole,with potentiometer R66 included. Oak Type N or Grigsby-Allison Type 4M-LW.	C-7773767-P4
S7 and S8	Rotary switches: dp, 2 positions, nonshorting type. Centralab Type 1464.	K-112J201-P1
*S9	Toggle switch: spst, 3 amp at 250 v. Arrow Hart and Hegeman Type 20994-WJB.	M-7478623-P1
S10	Rotary switch: 1 section, 9 positions, 1 pole. Oak Type N or Grigsby-Allison Type 4M-LW.	C-7773767-P5
	TRANSFORMER	
T1	Plate and filament transformer.	C-7773768-P1
	TUBES	
V1	Type 5879.	
V2	Type 5879.	
V3	Type 6BK7.	
V4	Type 6BK7	
V5	Type 5879.	
V6	Type 5879.	

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	TUBES (CONTINUED)	
V7	Type 6BK7.	
V8	Type 6BK7.	
V9	Type 884.	
V10	Type 12AU7.	
V11	Type 12AU7.	
V12	Type 5UP1. (4ST2B1 only.)	
V12	Type 5UP7. (4ST2B2 only.)	
V12	Type 5UP11. (4ST2B3 only.)	
V13	Type 1B3-GT.	
V14	Type 5Y3-GT.	
V15	Type 0A2.	
	SOCKETS	
*XF1	Fuse holder. Bussman Type HKP.	K-7115179-P1
XI1	Jewel light assembly: smooth, frosted back red jewel. Drake Cat.#40.	K-7102418-P4
*XRT1	Ballast resistor socket: mica filled phenolic, octal. Cinch Type 9886.	K-7103053-P1
*XV1 and XV2	Tube socket: mica filled phenolic, 9 pin miniature. RTMA Type TSE9T201.	M-7480532-P3
*XV3 and XV4	Tube socket: mica filled phenolic, 9 pin miniature, 4 ground ears.	M-7480532-P8
*XV5 and XV6	Tube socket: mica filled phenolic, 9 pin miniature. RTMA Type TSE9T201.	M-7480532-P3
*XV7 and XV8	Tube socket: mica filled phenolic, 9 pin miniature, 4 ground ears.	M-7480532-P8

*This item or equivalent should be obtained from a local radio dealer.

Symbol	Description	G-E Drawing
	SOCKETS (CONTINUED)	
*XV9	Tube socket: mica filled phenolic, octal. Cinch Type 9886.	K-7103053-P1
*XV10 and XV11	Tube socket: mica filled phenolic, 9 pin miniature, 4 ground ears.	M-7480532-P8
XV12	Tube socket: 12 pin. Ucinite Cat. #115227.	M-103J243-P2
*XV13 and XV14	Tube socket: mica filled phenolic, octal. Cinch Type 9886.	K-7103053-P1
*XV15	Tube socket: mica filled phenolic, 7 pin miniature. RTMA Type TSE7T203.	P-7768887-P4

*This item or equivalent should be obtained from a local radio dealer.

PRODUCTION CHANGE SHEET

OSCILLOSCOPE

MODELS 4ST2B1, 4ST2B2, 4ST2B3

The production changes listed below have been made on the Oscilloscopes, Models 4ST2B1, 2, and 3, whose nameplates are stamped Revision A or Revision B. This information is not intended to be used to modify equipments whose nameplates are not so stamped. The Revision letter should be mentioned in any correspondence.

REVISION A

Parts List

Symbol	Was	Changed to
CR1	Added.	
S5	Rotary switch: spdt, nonshorting type contacts. Oak Type 23. G-E Drawing A-7136232-P1.	Rotary switch: Similar to Centralab Type 6BX. Nonshorting type contacts, 2 positions. G-E Drawing A-7140192-P1.

REVISION B

Rev. B includes Rev. A plus the following:

Parts List

Symbol	Was	Changed to
C49	Pyranol, 0.50 mfd ± 10%, 2000 v d-c w. G-E Cat. #23F380. G-E Dwg. C-7773777-P2.	Same, except welded flag construction.
R72	Composition, 1000 ohms ± 10%, 1/2 w.	Not used. Replaced with a bus wire located on S6.
R111	Composition, 0.10 megohm ± 10%, 1/2 w.	Composition, 36,000 ohms ± 5%, 1/2 w. G-E Dwg. C-3R77-P363J.
R115 and R116	Not used.	Composition, 82,000 ohms ± 10%, 2 w. G-E Dwg. C-3R79-P823K.

Symbol	Was	Changed to
V1 and V2	Unmatched pair.	Matched pair.
V5 and V6	Unmatched pair.	Matched pair.

Elementary Diagram, Fig. 14

R115 and R116 are connected in parallel with R91.

A jumper is added from arm of R89 (Intensity) to junction of R89, R90 and C49.

R72 is removed and replaced with a bus wire located on S6.

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